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EVALUATION OF CANMET'S FOSSIL FUEL HEATING PROGRAM

FINAL REPORT

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Submitted by:

Marbek Resource Consultants Ltd.

In Association with:

James F. Hickling Ltd.

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Marbek
Resource
Consultants
Ltd.

Suite 407
2211 Riverside Drive
Ottawa, Canada
K1H 7X5
(613) 523-0784

David Brooks
Brian Kelly
George Matheson
Roger Peters
Paul Robillard

ABSTRACT

Since the first "oil crisis" fourteen years ago, there have been substantial improvements in the combustion efficiency of Canadian residential heating equipment. Throughout this period, the Canada Centre for Mineral and Energy Technology (CANMET), a branch of Energy, Mines and Resources Canada, not only initiated, but financially and technically supported, many of these improvements through its Fossil Fuel Heating Program.

This study documents CANMET's research and technology transfer activities in residential heating systems and evaluates the impact of these activities on Canadian consumers and residential heating equipment manufacturers as well as on the numerous government agencies, industry associations and consumer organizations which have a stake in new and improved residential heating technologies.

The study concludes that the Fossil Fuel Heating Program provided very substantial economic benefits to Canadian consumers, heating equipment manufacturers and other non-manufacturing organizations. Total quantified benefits were estimated to be in 1987 present value terms at least $31.2 million, compared with program costs of $12.3 million. The Program is an excellent model for government involvement in industrial R&D and product development; the key to the Program's overall influence, leadership and acceptance is its combination of technical capability and unbiased approach to the technologies involved. The study also proposes several means to further improve the Program's efficiency and effectiveness and recommends not only continuation of the Program, but also modest expansion of the resources allocated to it.

RÉSUMÉ

Depuis la première "crise du pétrole", il y a quinze ans, l'efficacité de la combustion dans les systèmes de chauffage des maisons canadiennes s'est sensiblement améliorée. Le Centre canadien de la technologie des minéraux et de l'énergie (CANMET), une direction d'Énergie, Mines et Ressources Canada, a non seulement lancé mais aussi financièrement et techniquement appuyé beaucoup de ces améliorations par son Programme de chauffage par les combustibles fossiles.

Cette étude décrit les travaux de recherche et de transfert de technologies de CANMET dans les systèmes de chauffage résidentiel et évalue l'importance de ces travaux pour les consommateurs et les fabriquants de matériel de chauffage résidentiel au Canada, de même que pour les nombreux organismes gouvernementaux, associations industrielles et regroupements de consommateurs qui s'intéressent à l'amélioration des technologies de chauffage résidentiel et à la découverte de nouvelles technologies.

L'étude conclut que le Programme de chauffage par les combustibles fossiles a procuré des avantages économiques très appréciables aux consommateurs canadiens, aux fabricants de matériel de chauffage et à des organisations appartenant à d'autres domaines. Si l'on quantifie en valeurs actuelles (1987) l'ensemble des avantages ainsi apportés, le chiffre s'élève à au moins 31,2 millions de dollars, comparativement aux 12,3 millions que le Programme a coûté. Ce programme constitue un excellent modèle de participation gouvernementale à la recherche et au développement industriels et à la mise au point de produits; s'il a exercé une telle influence et s'il a été si bien accepté, dans l'ensemble, c'est principalement dû à son alliage de compétences techniques et d'approches objectives des technologies utilisées. L'étude propose aussi plusieurs moyens d'améliorer encore l'utilité et l'efficacité du programme et recommande non seulement de le poursuivre mais aussi d'accroître, ne serait-ce que modestement, les ressources qui lui sont consacrées.

EXECUTIVE SUMMARY

BACKGROUND

The Canada Centre for Minerals and Energy Technology (CANMET), a branch of Energy, Mines and Resources Canada, has initiated, as well as technically and financially supported, research and technology transfer on residential heating from 1971 to the present under its Fossil Fuel Heating Program. Since its inception in 1971, the Program has been implemented by CANMET's Combustion and Carbonization Research Laboratory (CCRL) located at the Bell's Corners Complex.

The Program has defined 5 target technologies:

- oil-fired heating equipment
- gas-fired heating equipment
- wood combustion heating equipment
- alternate heating fuels
- air quality and venting systems.

This evaluation study, based primarily on 50 detailed interviews with the Program's major client groups, documents and evaluates the effectiveness of the research and technology transfer activities, undertaken or funded by CANMET, on residential heating from 1971 to present.

MAJOR FINDINGS

1. PROGRAM APPROACH AND ACTIVITIES

THE PROGRAM HAS DEVELOPED AN EFFECTIVE APPROACH TO TECHNOLOGY DEVELOPMENT AND TRANSFER.

- The Program combines research and development in the laboratory with field trials in private homes.

- The Program's involvement in information transfer, liaison and standards development activities is effective in moving research and development results into the market place.

- The linkages, which the Program has established and nourished with virtually every Canadian organization involved in the delivery of home heating products and services, provide valuable feedback from the market place.

2. INDUSTRY PERCEPTION OF THE PROGRAM

THE PROGRAM IS WIDELY ACKNOWLEDGED TO BE AN EXCELLENT MODEL FOR GOVERNMENT INVOLVEMENT IN INDUSTRIAL RESEARCH AND DEVELOPMENT AND IN PRODUCT DEVELOPMENT. THE PROGRAM PROVIDES GUIDANCE AND LEADERSHIP TO ALL SEGMENTS OF THE HOME HEATING INDUSTRY.

- The Program keeps 2 to 3 years ahead in technology development and therefore helps manufacturers, standards organizations and government policy and program personnel to anticipate problems and to develop solutions when a new technical problem or market demand arises.

- The Program's combination of technical capability and neutrality inspires a unique level of industry and consumer acceptability and credibility. Thus the Program is able to play the important role of arbiter in areas of technical controversy.

- The Program's acceptability and credibility is further enhanced because it provides a Canadian perspective; it deals with Canadian products, markets and climate conditions.

- 49% of the manufacturers reported that the Program had exerted either a strong or moderate influence on their firm's product development decisions.

- Over 90% of the respondents from the non-manufacturing sectors reported that if the Program did not exist, it would need to be created to meet the needs of their organizations.

- The Program enjoys an international reputation for its technical capability in home heating systems and has provided valuable input to many foreign organizations.

3. NEW TECHNOLOGY DEVELOPMENTS AND IMPACTS

FROM 1971 TO PRESENT, SUBSTANTIAL EFFICIENCY, SAFETY AND EMISSION IMPROVEMENTS TO OIL, GAS AND WOOD HEATING APPLIANCES HAVE TAKEN PLACE. TODAY, CONSUMERS HAVE A WIDE CHOICE OF IMPROVED HEATING PRODUCTS, AND SALES DATA SHOW THAT THESE NEW, MORE EFFICIENT HEATING APPLIANCES ARE GAINING SIGNIFICANT MARKET PENETRATION. AS A RESULT OF THE COOPERATIVE EFFORTS OF THE PROGRAM AND THE HOME HEATING INDUSTRY:

- Virtually all new oil furnaces are equipped with high efficiency burners, providing seasonal efficiencies in the range of 70-75%. Furthermore, new, non-condensing oil furnaces, providing seasonal efficiencies in the range of 85-87%, are now available and expected to show good sales penetration in the near future. In 1971, the standard oil furnace operated with a seasonal combustion efficiency of about 55-60%.

- Mid-efficiency and condensing gas furnaces, providing seasonal efficiencies in the range of 80-85% and 90-95% respectively, represent currently about 30-40% of new gas furnace sales. This market share is expected to increase to over 50% by 1990, with sales of the mid-efficiency units being particularly strong. In 1971, the standard gas furnace operated with a seasonal combustion efficiency of about 55-60%.

- New advanced wood stove designs not only provide efficiencies approaching 80%, compared with a 1971 standard efficiency of 50% or less, but they also burn much cleaner and they are safer and more convenient to use.

- Products have also been developed and certified for retrofit applications. These products, principally the flame retention head retrofit burner for oil furnaces and the retrofit condensing gas furnace, provide potential fuel efficiency improvements of 10-20% and 25-30%, respectively. Sales of these products have, however, been limited to a few hundred per year.

- New hybrid (space and water heating) gas and oil systems are beginning to enter the market and are especially suited to the reduced thermal needs of low energy housing.
- Export sales of Canadian manufactured furnaces and wood stoves have also increased substantially over the period 1971-1986. In 1971, export sales reported by the manufacturers sampled were less than 2% of their production; however, by 1986, this number had risen to 30%.

4. PROGRAM COST-BENEFIT

THE PROGRAM HAS PROVIDED SUBSTANTIAL NET ECONOMIC BENEFITS TO CANADIAN CONSUMERS, HEATING EQUIPMENT MANUFACTURERS AND OTHER NON-MANUFACTURING ORGANIZATIONS. THE STUDY ESTIMATED PROGRAM COSTS TO DATE IN 1987 PRESENT VALUE TERMS TO BE $12.3 MILLION, COMPARED WITH TOTAL QUANTIFIED NOMINAL BENEFITS OF AT LEAST $31.2 MILLION.

- The study's scope did not include a formal cost-benefit analysis. Therefore, the following quantified benefits represent a conservative estimate:

Nominal benefit to homeowners from energy savings:	**$17.80 million**
Nominal benefit to manufacturers from increased export sales:	**1.16 million**
Benefits to other non-manufacturing constituencies	**12.30 million**
Total:	**$31.26 million**

- Quantified costs consisted of:

Labour, capital and O&M costs	**$10.60 million**
External contracts	**1.70 million**
Total:	**$12.30 million**

5. THE PROGRAM'S FUTURE

THE STUDY IDENTIFIED VERY STRONG SUPPORT NOT ONLY FOR CONTINUATION OF THE PROGRAM, BUT ALSO FOR EXPANSION OF THE RESOURCES ALLOCATED TO IT. APPROXIMATELY 90% OF THE RESPONDENTS CITED THE CONTINUING RAPID DEVELOPMENTS IN HOME HEATING TECHNOLOGIES AS EVIDENCE OF THE NEED FOR THE PROGRAM TO CONTINUE IN ITS PRESENT ROLE; APPROXIMATELY 10% OF

THE RESPONDENTS ALSO INDICATED THAT THE PROGRAM'S SCOPE OF ACTIVITIES SHOULD BE EXPANDED. NONE SUGGESTED A DECREASE IN THE PROGRAM'S ACTIVITIES.

. Several respondents, from both the manufacturing and non-manufacturing constituencies, cited the potential Free Trade Agreement with the U.S. as a particular case which could significantly increase their requirements for access to the Program's services.

. Respondents from both the manufacturing and non-manufacturing constituencies were very consistent in their critiques of the current Program and in many of their suggested changes. Their critiques and suggested changes related to increased access to the Program's highly respected knowledge base as well as to increased access to senior Program staff time. Specific suggestions included the following.

  - The Program should establish a regular newsletter.

  - The Program should be allocated increased administrative and technical personnel resources to permit a wider distribution of responsibilities and a more timely response by senior staff.

  - The Program should provide improved telephone access to its personnel. The current switchboard at CANMET's Bell's Corners Complex was frequently cited as a source of frustration for those attempting to contact Program personnel.

6. CONCLUSIONS AND RECOMMENDATIONS

The study concludes that the Fossil Fuel Heating Program has provided substantial net benefits to Canadian society. The Program is widely respected by all parties involved with it and has developed an international reputation for its excellence in fossil fuel combustion research and development. The technical expertise provided by the Program is undoubtedly one of the significant elements contributing to the international recognition of the high quality of Canadian residential furnaces. Furthermore, the role played by the Program is widely recognized as being an excellent model for government involvement in industrial R&D and product development. The combination of technical capability and neutral approach to the technologies involved is particularly critical to the Program's overall influence, leadership and acceptance. The extensive list of new product developments being launched or planned for market entry further justifies the recommendation to continue the Program. The study concludes that a modest expansion of the Program's resources is also justifiable.

Finally, it is also evident that the Program's efficiency and effectiveness can be augmented by increased senior management attention to the administrative and communications issues cited.

SOMMAIRE

INTRODUCTION

Le Centre canadien de la technologie des minéraux et de l'énergie (CANMET), une direction d'Énergie, Mines et Ressources Canada, a entrepris ou techniquement et financièrement secondé des travaux de recherche et de transfert technologique sur le chauffage domiciliaire, en vertu de son Programme de chauffage aux combustibles fossiles. Créé en 1971, le Programme a été mis en oeuvre par le Laboratoire de recherches sur la combustion et la carbonisation de CANMET, au Complexe de Bell's Corners.

Le Programme porte sur cinq technologies :

- l'équipement de chauffage au mazout
- l'équipement de chauffage au gaz
- l'équipement de chauffage au bois
- les combustibles de remplacement
- la qualité de l'air et les systèmes d'évacuation

Cette étude, qui s'appuie principalement sur 50 entrevues détaillées avec les principaux groupes clients du Programme, documente et évalue l'efficacité des travaux de recherche et de transfert technologique sur le chauffage domiciliaire, entrepris ou financés par CANMET depuis 1971.

PRINCIPALES CONSTATATIONS

1. ACTIVITÉS DU PROGRAMME ET MÉTHODE UTILISÉE

LE PROGRAMME A MIS AU POINT UNE MÉTHODE EFFICACE DE DÉVELOPPEMENT ET DE TRANSFERT DE TECHNOLOGIE.

- Le Programme allie la recherche et le développement en laboratoire à des essais dans des maisons privées.
- La participation du Programme aux activités de liaison, de transfert d'information et d'établissement de normes joue un rôle efficace pour transposer sur le marché les résultats de la recherche et du développement.
- Les liens que le Programme a noués et entretenus avec à peu près toutes les organisations canadiennes s'occupant de produits et de services de chauffage domiciliaire permettent de connaître très utilement les réactions du marché.

2. PERCEPTION DU PROGRAMME PAR L'INDUSTRIE

LE PROGRAMME EST LARGEMENT RECONNU COMME UN EXCELLENT MODÈLE DE PARTICIPATION GOUVERNEMENTALE À LA RECHERCHE ET AU DÉVELOPPEMENT INDUSTRIELS ET À LA MISE AU POINT DE PRODUITS. IL FOURNIT DE PRÉCIEUX RENSEIGNEMENTS ET DONNE LE TON À TOUS LES SECTEURS DE L'INDUSTRIE DU CHAUFFAGE DOMICILIAIRE.

- Le Programme a de deux à trois ans d'avance en matière de développement technologique et aide en conséquence les fabricants, les organismes de normalisation et les responsables des politiques et des programmes du gouvernement à prévoir les difficultés et à trouver des réponses lorsque de nouveaux problèmes techniques surgissent ou que le marché réclame de nouveaux produits.

- Parce que le Programme allie compétence technique et neutralité, il revêt un niveau particulier d'acceptabilité et de crédibilité auprès de l'industrie et des consommateurs, ce qui le rend apte à jouer le rôle important d'arbitre dans les domaines de controverse technique.

- Cette acceptabilité et cette crédibilité sont encore plus fortes du fait que le Programme offre une perspective canadienne : il porte sur les produits, les marchés et le climat canadiens.

- Parmi les fabricants, 49 p. 100 ont déclaré que le Programme avait fortement ou modérément influencé leurs décisions relatives au développement des produits.

- Plus de 90 p. 100 des répondants des secteurs autres que la fabrication ont affirmé que, si le Programme n'existait pas, il faudrait le créer pour répondre aux besoins de leur organisation.

- Le Programme s'est acquis une réputation internationale pour sa compétence technique dans les systèmes de chauffage domiciliaire et a rendu de précieux services à beaucoup d'organisations étrangères.

3. MISE AU POINT ET INCIDENCE DES NOUVELLES TECHNOLOGIES

DEPUIS 1971, LE RENDEMENT, LA SÉCURITÉ ET LES SYSTEMES D'ÉVACUATION DES APPAREILS DE CHAUFFAGE AU MAZOUT, AU GAZ ET AU BOIS SE SONT GRANDEMENT AMÉLIORÉS. AUJOURD'HUI, LES CONSOMMATEURS ONT UN VASTE CHOIX DE MEILLEURS PRODUITS DE CHAUFFAGE ET LES CHIFFRES DES VENTES DÉMONTRENT QUE CES NOUVEAUX APPAREILS PLUS EFFICACES FONT D'IMPORTANTS GAINS SUR LE MARCHÉ. PAR SUITE DE LA COOPÉRATION QUI S'EST ÉTABLIE ENTRE LE PROGRAMME ET L'INDUSTRIE DU CHAUFFAGE DOMICILIAIRE :

- A peu près tous les nouveaux appareils au mazout sont munis de brûleurs à haut rendement dont le rendement saisonnier se situe entre 70 et 75 p. 100. De plus, de nouveaux appareils au mazout sans condensation, qui procurent un rendement saisonnier de 85 à 87 p. 100, sont maintenant disponibles et devraient bientôt accaparer une part importante du marché. En 1971, le système ordinaire au mazout n'offrait un rendement saisonnier de combustion que d'environ 55 à 60 p. 100.

- Les appareils à gaz à rendement intermédiaire et à condensation, qui procurent des rendements saisonniers de 80-85 p. 100 et 90-95 p. 100 respectivement, comptent actuellement pour environ 30 à 40 p. 100 des ventes de nouveaux appareils à gaz. Cette part du marché devrait grimper à plus de 50 p. 100 d'ici 1990; les ventes d'appareils à rendement intermédiaire devraient être particulièrement élevées. En 1971, l'appareil à gaz ordinaire affichait un rendement saisonnier de combustion d'environ 55 à 60 p. 100.

- De nouveaux poêles à bois perfectionnés permettent non seulement des taux de rendement de presque 80 p. 100, en comparaison de 50 p. 100 ou moins en 1971, mais aussi une combustion beaucoup plus nette tout en étant plus sûrs et plus commodes.

- Des produits ont également été mis au point et approuvés pour améliorer les appareils. Ces produits, principalement le brûleur à tête de retenue pour les appareils à mazout et les dispositifs de condensation pour les appareils à gaz, procurent des améliorations possibles de rendement de 10-20 p. 100 et 25-30 p. 100 respectivement. Les ventes de ces produits se limitent cependant à quelques centaines par année.

- Les nouveaux systèmes hybrides de chauffage (pour les pièces et pour l'eau) au gaz et au mazout commencent à percer le marché et conviennent spécialement aux besoins thermiques réduits des maisons à faible consommation énergétique.

- Les exportations de poêles à bois et d'autres appareils de chauffage fabriqués au Canada ont aussi notablement augmenté de 1971 à 1986. En 1971, les ventes à l'exportation déclarées par les fabricants correspondaient à moins de 2 p. 100 de leur production; en 1986 la proportion était grimpée à 30 p. 100.

4. COÛTS-AVANTAGES DU PROGRAMME

LE PROGRAMME A PROCURÉ D'IMPORTANTS AVANTAGES ÉCONOMIQUES NETS AUX CONSOMMATEURS CANADIENS, AUX FABRICANTS DE MATÉRIEL DE CHAUFFAGE ET À DES ORGANISATIONS NON RELIÉES À LA FABRICATION. L'ÉTUDE A CALCULÉ QUE LE PROGRAMME AVAIT COÛTÉ JUSQU'ICI 12,3 MILLIONS DE DOLLARS (VALEUR ACTUELLE DE 1987), COMPARATIVEMENT À DES AVANTAGES NOMINAUX QUANTIFIÉS S'ÉLEVANT EN TOUT AU MOINS À 31,2 MILLIONS DE DOLLARS.

- L'étude n'analyse pas les coûts-avantages en détail. Les avantages quantifiés suivants représentent donc une estimation prudente :

• Avantage nominal aux propriétaires en termes d'économies d'énergie :	**17,80 millions de dollars**
• Avantage nominal aux fabricants en hausse des ventes à l'exportation :	**1,16 millions de dollars**
• Avantages à d'autres éléments en dehors de la fabrication :	**12,30 millions de dollars**
Total :	**12,30 millions de dollars**

- Les coûts quantifiés comprenaient :

Main-d'oeuvre, investissements, bureau et administration	10,60 millions de dollars
Contrats externes	1,70 millions de dollars
Total :	12,30 millions de dollars

5. L'AVENIR DU PROGRAMME

L'ÉTUDE A RELEVÉ UN TRÈS FORT DÉSIR DE VOIR NON SEULEMENT POURSUIVRE LE PROGRAMME MAIS AUSSI ACCROÎTRE LES RESSOURCES QUI LUI SONT CONSACRÉES. ENVIRON 90 P. 100 DES RÉPONDANTS ONT DÉCLARÉ QUE L'AMÉLIORATION RAPIDE ET SOUTENUE DES TECHNOLOGIES DE CHAUFFAGE DOMICILIAIRE PROUVAIT LA NÉCESSITÉ DE POURSUIVRE LE PROGRAMME DANS SON RÔLE ACTUEL; ENVIRON 10 P. 100 DES RÉPONDANTS SOUHAITAIENT EN OUTRE QUE LE CHAMP D'ACTIVITÉ DU PROGRAMME SOIT ÉLARGI. AUCUN N'A SUGGÉRÉ UNE DIMINUTION DE CES ACTIVITÉS.

- Plusieurs répondants, tant du secteur manufacturier que d'ailleurs, ont mentionné que l'accord possible de libre-échange avec les États-Unis pourrait sensiblement accroître leur besoin d'accès aux services du Programme.

- Les répondants tant du secteur manufacturier que d'ailleurs ont montré beaucoup de cohérence dans leurs critiques du programme actuel et dans bon nombre de suggestions de changement. Leurs critiques et leurs suggestions de changement portaient sur un accès accru au réservoir de connaissances hautement respectées du Programme et sur de meilleures possibilités de consultation avec le personnel supérieur du Programme. Mentionnons, entre autres suggestions, que :

  - Le Programme devrait se doter d'un bulletin régulier.

  - Le Programme devrait bénéficier de ressources plus considérables en personnel administratif et technique afin de permettre des réponses plus rapides de la part du personnel supérieur et une plus large répartition des responsabilités.

  - Le Programme devrait améliorer l'accès à son personnel par téléphone. Le standard téléphonique du Complexe de CANMET, à Bell's Corners, a fréquemment été cité comme source de frustration pour les gens qui veulent communiquer avec le personnel du Programme.

6. CONCLUSIONS ET RECOMMANDATIONS

L'étude conclut que le Programme de chauffage aux combustibles fossiles a procuré d'importants avantages nets à la société canadienne. Il est hautement respecté par toutes les parties intéressées et s'est taillé une réputation internationale d'excellence dans la recherche et le développement en matière d'utilisation de combustibles fossiles. Les connaissances techniques engendrées par le Programme constituent sans nul doute l'un des principaux éléments qui ont contribué à faire reconnaître internationnalement la haute qualité des appareils de chauffage domiciliaire fabriqués au Canada. De plus, le rôle joué par le Programme est largement reconnu comme un excellent modèle de participation gouvernementale à la recherche et au développement industriels et à la mise au point de produits. Si le Programme a exercé une telle influence et s'il a été si bien accepté, c'est principalement dû à son alliage de compétence technique et de perception objective des technologies utilisées. La longue liste de nouveaux produits à l'étude ou en voie de lancement sur le marché justifie encore plus la poursuite du Programme. L'étude conclut qu'une modeste augmentation des ressources attribuées au Programme est également justifiable.

Enfin, il va de soi que le Programme y gagnera encore en utilité si la direction supérieure prête davantage attention aux points relevés plus haut en matière d'administration et de communications.

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SECTION 1
INTRODUCTION

1.1 BACKGROUND

Marbek Resource Consultants Ltd., in association with James F. Hickling Ltd., has been contracted by the Canada Centre for Mineral and Energy Technology (CANMET) to carry out an evaluation of the research and technology transfer activities undertaken or funded by CANMET on residential heating from 1971 to 1986 under its Fossil Fuel Heating Program (FFH Program).

More specifically, the objective of this project is:

> "To evaluate quantitatively and qualitatively the technical, economic and social impacts on Canadian consumers, arising from CANMET's research in residential heating".

1.2 APPROACH

The study has been carried out in two phases. In Phase I, interviews were conducted with personnel from CANMET's FFH Program to define and develop a preliminary documentation of:

- the Program's objectives, activities and outputs over the period 1971-1986
- the key organizations, firms and government departments (referred to herein as constituencies) with whom the Program is, and has been, involved over the period, and
- the financial and personnel resources applied to the Program over the period.

In addition to documenting the above Program facets, Phase I also identified and presented the key issues to be probed during Phase II in which a cross-section of those constituencies which are actively involved and influential in the development and provision of Canadian home heating products and services were interviewed. In selecting constituencies to be interviewed, emphasis was placed on those organizations, firms, etc. which were known to have had contact with the program over its duration. However, other firms, organizations and government departments were also randomly selected in order to gain a balance of views. Figure 1.1 presents a breakdown by constituency.

FIGURE 1.1
INTERVIEW SAMPLE

	Constituency	Interviews Conducted
1.	Equipment Manufacturers	15
2.	Heating Industry Associations	5
3.	Standards Development Organizations	4
4.	Federal Government Departments	10
5.	Provincial/Territorial Government Departments	4
6.	Building Designers	2
7.	Oil/Gas Companies	3
8.	Consumer Organizations	3
9.	Community Colleges	2
10.	Research Laboratories (including U.S.)	2
	Total:	50

Two separate interview protocols were developed: one for equipment manufacturers and one for the non-manufacturing constituencies. Copies of each are provided in Appendix A. In broad terms, the key issues were:

- Identification of each organization's or firm's major home heating activities or products and their respective achievements.
- Identification and assessment of the extent to which CANMET's FFH Program has supported those achievements, including incrementality assessment, where possible.
- Identification and assessment of the relative value to the organization of each of the major FFH Program activity areas and outputs.
- Identification of each organization's or firm's future program or product development objectives.
- Identification of any changes to the current FFH Program that would assist each organization or firm to more effectively meet their objectives.

Following client approval of the interview sample and interview protocol, the study proceeded to Phase II.

In Phase II, interviews of approximately 1 to 1.5 hours were carried out with each interviewee. The evaluation provided herein is based on an analysis of the results of these interviews, combined with a review of program documents, other literature sources, and related industry statistics.

1.3 REPORT PRESENTATION

The study results are presented in 4 sections. Following this introductory section:

- Section 2 provides an overview of the FFH Program, including a review of the Program's objectives, major activity streams, resource allocations, etc. throughout the period 1971 to present.
- Section 3 provides more specific documentation of major Program activities and outputs, both chronologically and from the perspective of each of the major home heating sectors (or constituencies) with whom the Program interacts.
- Finally, in Section 4, the key evaluation findings are presented together with the project team's conclusions and recommendations.

It should be noted that in this context, fossil fuel also includes wood.

SECTION 2
OVERVIEW OF CANMET'S FOSSIL FUEL HEATING PROGRAM

2.1 INTRODUCTION

This Section documents CANMET's Fossil Fuel Heating Program with specific focus on the following areas:

- Overview of the organization and mission of CANMET, as it pertains to the Fossil Fuel Heating Program (FFH Program).
- Identification of the Fossil Fuel Heating Program's objectives, its technology foci and its major activity areas.
- Identification of the Program's linkages with other segments of the home heating industry.
- Program resource allocation.

Each of the above areas is briefly described in the text below; additional details related to program activities and outputs are provided in Section 3 as well as in Appendix B.

2.2 CANMET

The Canada Centre for Mineral and Energy Technology (CANMET) serves as the major technological research arm of the federal Department of Energy, Mines and Resources. Established in 1907 as the federal Mines Branch, its original mandate was directed towards meeting the research and development needs of Canada's (then) emerging mining industry. However, over time the Branch's scope of work continued to grow and in 1974, it was reorganized and renamed to reflect its involvement in activities related to both minerals and energy technologies.

The Centre's mandate and related activities are defined in the following excerpt:

> The mission of CANMET, reaffirmed in 1982, is to enhance the role and contribution of minerals and energy to the Canadian economy by means of mission-oriented research and development in mining, mineral processing and utilization of metals, industrial minerals and fuels, which:
>
> - provide information to the minister for making nonrenewable resource related policies;
> - serve government and social objectives for health and safety and the environment; and
> - are supportive to R&D performed by industry in order to improve the economic performance and productivity of industry.

> To fulfill its mandate, CANMET carries out basic and applied research, development, demonstration and transfer of new technology to industry. This work is not carried out in isolation--close links are maintained with industry and other research organizations to ensure that all projects are undertaken in response to, or in anticipation of, real needs and problems.*

The general organization chart for CANMET, applicable throughout the majority of the program period, is provided in Figure 2.1 (overleaf). As illustrated, the Centre's work is carried out in a number of laboratories and pilot plants located in Ottawa and several other locations. For the purposes of this study, two of the divisions shown in Figure 2.1, both located in the National Capital Region, are particularly relevant. They are:

- The Combustion and Carbonization Research Laboratory (CCRL).
- The Office of Technology Transfer, and

The Combustion and Carbonization Research Laboratory (CCRL), is the laboratory responsible for the implementation of the Fossil Fuel Heating Program, the focus of the present study.

The Office of Technology Transfer, which is the sponsor of this evaluation study, is responsible for techno-economic studies and the promotion and facilitation of technology transfer from CANMET to Canadian industry.

Most of CANMET's research in combustion is directed at the more efficient use of fuels and most of this work is actually carried out by CANMET's Combustion and Carbonization Research Laboratory (CCRL). Figure 2.2 situates the Fossil Fuel Heating Program in relation to the other major CCRL program areas. It shows that the FFH Program is one of three major conservation programs currently being conducted within CCRL's combustion division.

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* Energy, Mines and Resources Canada, CANMET: Technologies to Unlock Our Resources.

FIGURE 2.1

CANMET
Canada Centre for Mineral and Energy Technology (1986)

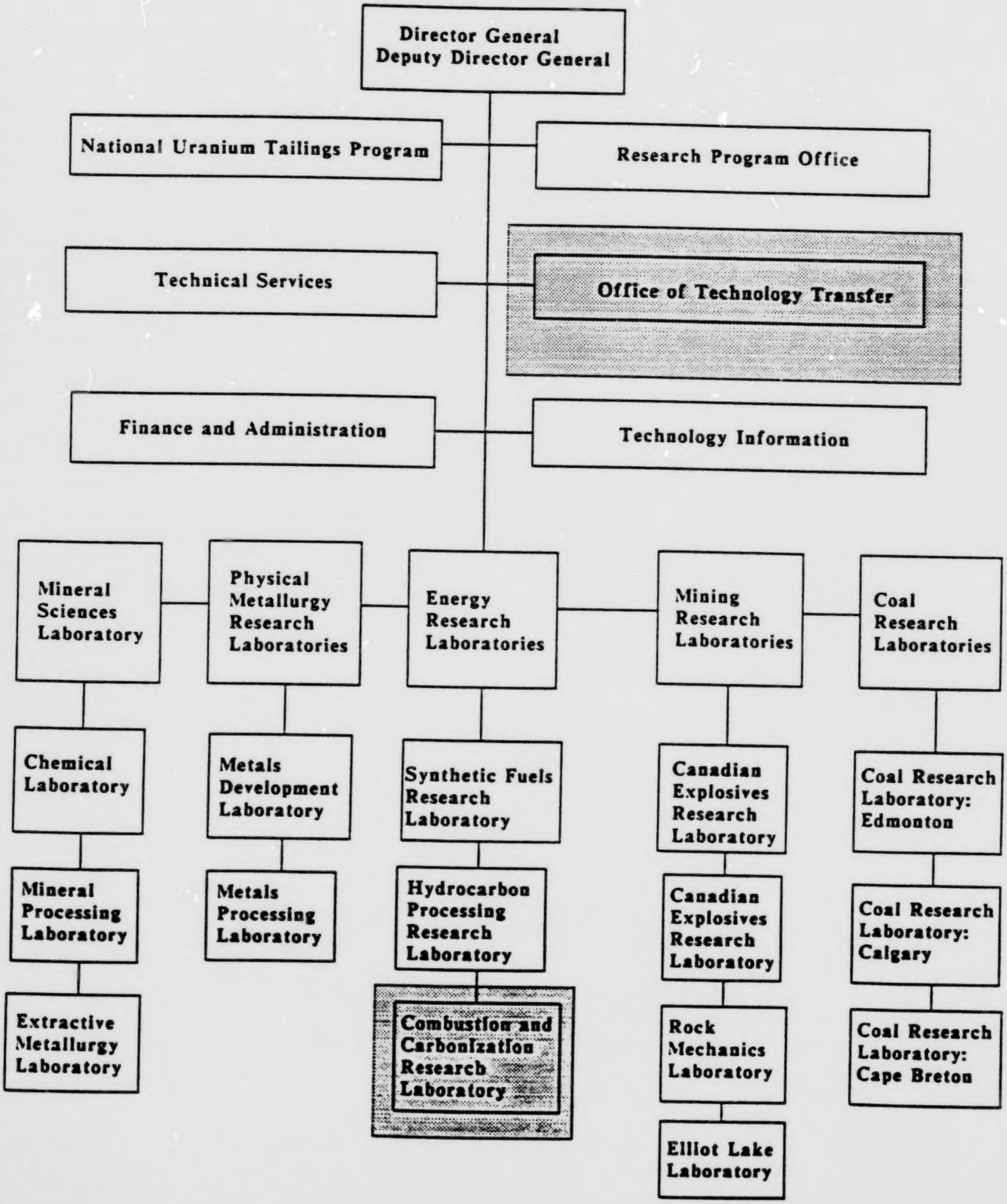
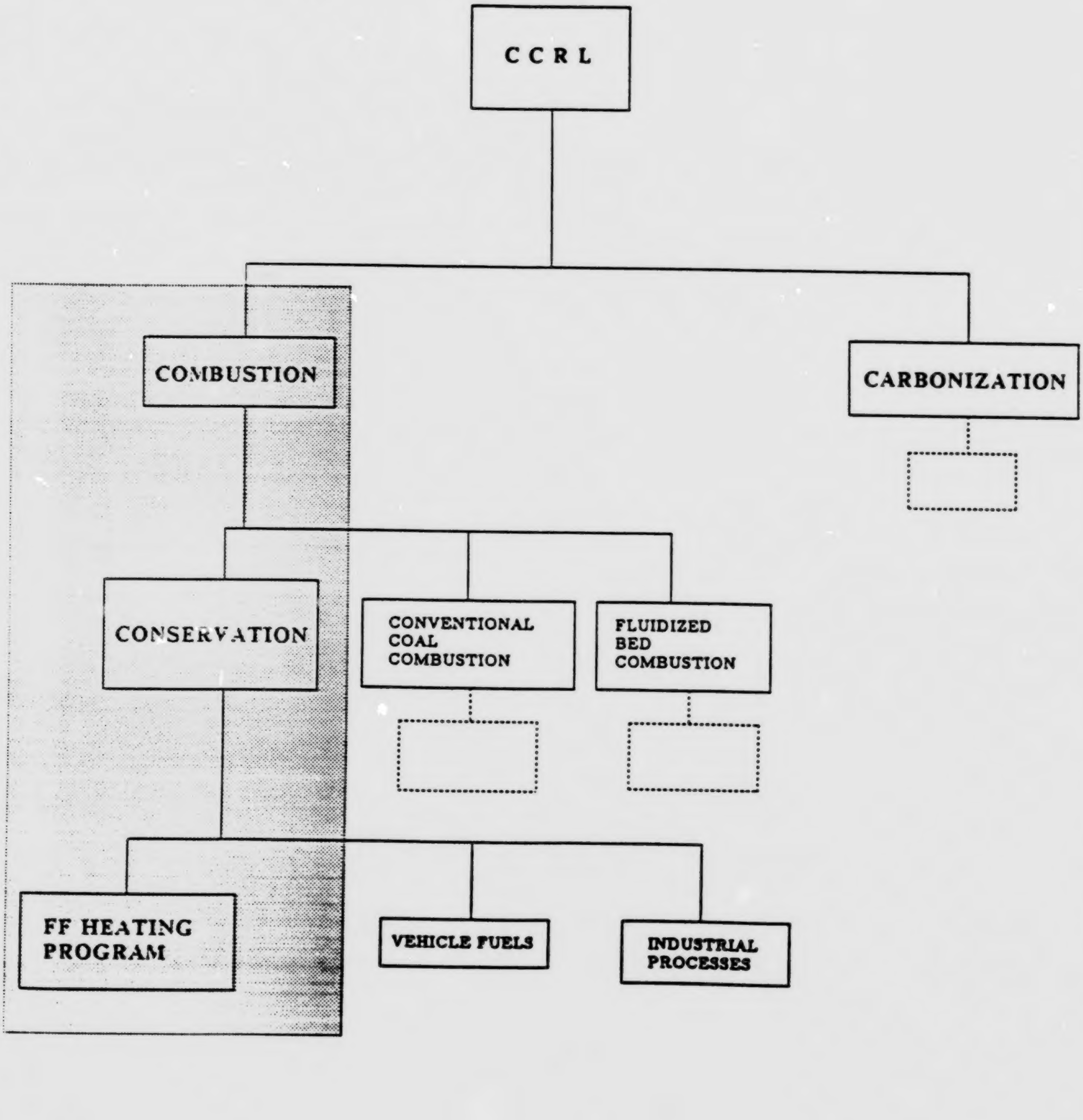

Director General
Deputy Director General
National Uranium Tailings Program
Research Program Office
Technical Services
Office of Technology Transfer
Finance and Administration
Technology Information
Mineral Sciences Laboratory
Physical Metallurgy Research Laboratories
Energy Research Laboratories
Mining Research Laboratories
Coal Research Laboratories
Chemical Laboratory
Mineral Processing Laboratory
Extractive Metallurgy Laboratory
Metals Development Laboratory
Metals Processing Laboratory
Synthetic Fuels Research Laboratory
Hydrocarbon Processing Research Laboratory
Combustion and Carbonization Research Laboratory
Canadian Explosives Research Laboratory
Canadian Explosives Research Laboratory
Rock Mechanics Laboratory
Elliot Lake Laboratory
Coal Research Laboratory: Edmonton
Coal Research Laboratory: Calgary
Coal Research Laboratory: Cape Breton

Figure 2.2

CCRL/Fossil Fuel Heating Program


CCRL
COMBUSTION
CARBONIZATION
CONSERVATION
CONVENTIONAL COAL COMBUSTION
FLUIDIZED BED COMBUSTION
FF HEATING PROGRAM
VEHICLE FUELS
INDUSTRIAL PROCESSES

2.3 THE FOSSIL FUEL HEATING PROGRAM

A logic diagram, illustrating the Program's primary objective, together with its major activity streams and related outputs and impacts, is presented in Figure 2.3. Each major element is discussed briefly below and further specific details related particularly to activities and outputs are presented in the following Section 3 as well as in Appendix B.

2.3.1 Program Objectives and Technology Foci

The Fossil Fuel Heating Program was initiated in 1971, two years prior to the onset of the first "oil crisis". Throughout the Program's history, its major objective has been, and continues to be:

> "To reduce consumption of fuels for space and service water heating through improved combustion technology and the optimization of operational conditions, while ensuring safe operating conditions and minimal impingement on the environment".

In pursuing the above objective, the Program has defined five target technology areas:

- Oil-fired heating equipment
- Gas-fired heating equipment
- Wood combustion heating equipment
- Alternate heating fuels
- Air quality and exhaust systems

2.3.2 Program Activity Streams

As illustrated in Figure 2.3, the Program's activities have been organized into four major streams. These are:

- Research and Development
- Liaison
- Information Transfer
- Standards Development

Each is briefly reviewed below; further details are provided in subsequent sections of this report.

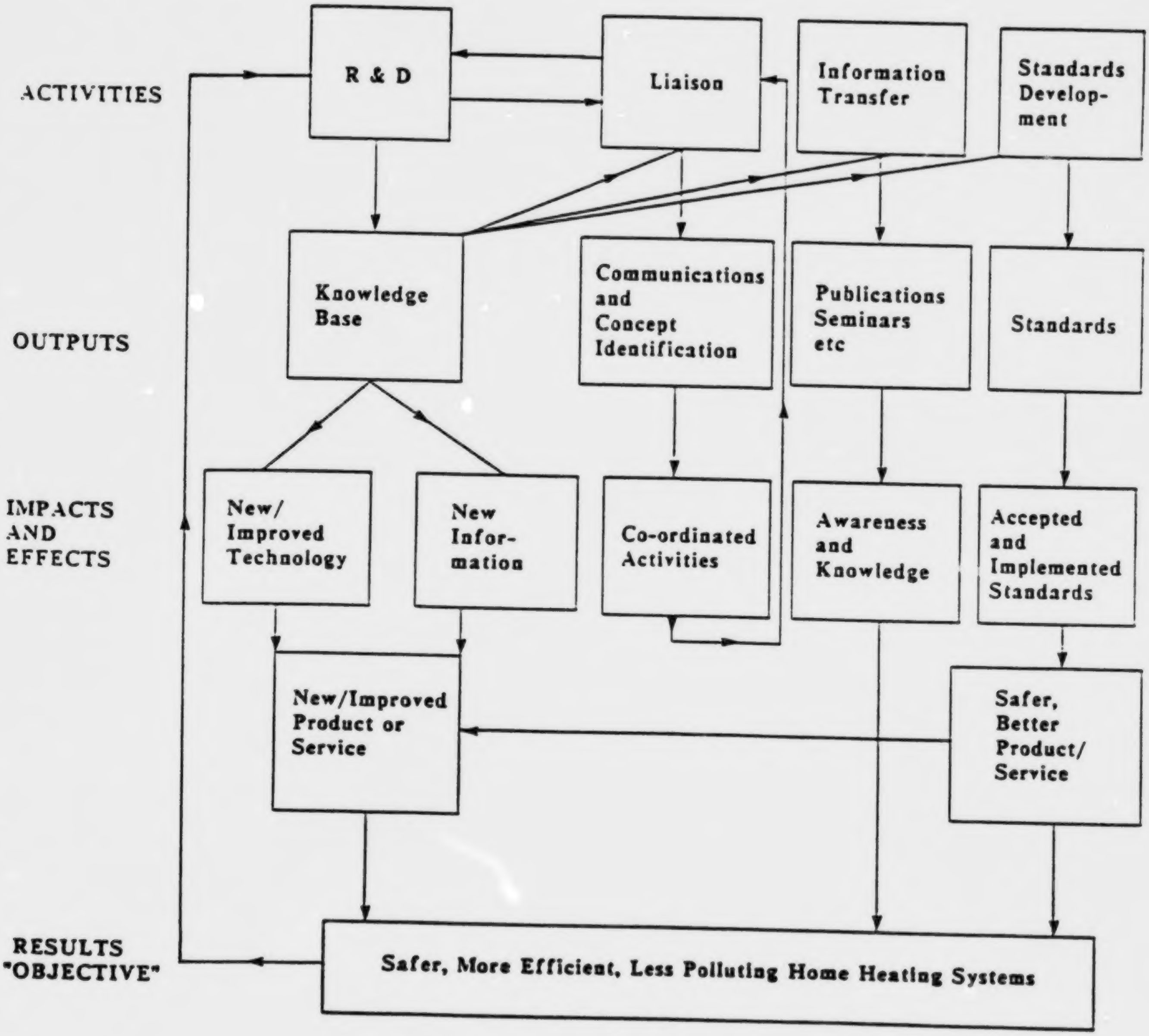
Research and Development: The Program's R&D activities include both in-house laboratory research and development work, frequently supported by actual field trials, and the issuing and supervision of selected contracts for pursuing the development of specific technology advancements.

In general, the Program's specific R&D activities have, to date, been initiated as a result of:

- opportunities identified solely by program personnel;
- opportunities identified in collaboration with residential heating equipment manufacturers, other industry or government agencies; and

FIGURE 2.3

CANMET/CCRL Fossil Fuel Heating Program
LOGIC DIAGRAM


ACTIVITIES
R & D
Liaison
Information Transfer
Standards Development
OUTPUTS
Knowledge Base
Communications and Concept Identification
Publications Seminars etc
Standards
IMPACTS AND EFFECTS
New/ Improved Technology
New Information
Co-ordinated Activities
Awareness and Knowledge
Accepted and Implemented Standards
New/Improved Product or Service
Safer, Better Product/ Service
RESULTS "OBJECTIVE"
Safer, More Efficient, Less Polluting Home Heating Systems

- needs identified by government agencies or industry, requiring the resolution of specific technology "bottlenecks" that impede the commercialization or wider implementation of a given technology.

Regardless of the "initiation source" of specific R&D activities, there is no doubt among Program personnel that R&D is the core element of the Program's activities. The results achieved in the laboratory and in actual field trials provide both the knowledge base and the practical experience that enable program personnel to function with credibility in other Program activity areas. Examples of R&D outputs are presented in the following Section 3.

Liaison: In parallel with the technology developments addressed through the Program's R&D activities, this activity stream seeks to address the host of human, policy, regulatory, etc. prerequisites necessary to move R&D results from the lab to the market place. Thus, it forms a distinct activity area in that activities provide important feedback and coordination support to the R&D and commercialization processes. Specific activities cover a wide range, including:

- identifying and promoting changes to outdated heating codes/regulations that may be impeding the market penetration of new technologies (e.g., fire safety codes formerly prevented retention head retrofits in certain locations).
- providing conceptual and technical input to the creation of new government programs and policies.
- providing a "networking" function so that key contributors are informed of relevant initiatives being undertaken by others, or in other jurisdictions.
- encouraging industry to incorporate new technologies or approaches into their product designs and services.
- participating in technical committees, including international agencies.

Although the specific outputs resulting from the Program's liaison activities often tend to be somewhat more difficult to document than those in other activity streams, Program personnel strongly emphasize the importance of this activity in actually ensuring that R&D results get to the market place.

Information Transfer: As illustrated by the extensive listing of outputs contained in Appendix B, Program personnel have been heavily involved in information transfer activities. In general, the Program's information transfer activities can be grouped into four broad categories:

- preparation of scientific and technical reports, publications and manuals including many simplified versions intended for less technically-oriented audiences,
- provision of formal teaching/training sessions as well as seminars and presentations to a variety of audiences,

- staging media interviews and preparing articles for various print media,
- consultation and enquiry response in writing and by telephone.

The Program's technology transfer activities and outputs seek to increase the level of awareness and technical knowledge among the full range of constituents involved in home heating. Thus, as illustrated by the listings provided throughout subsequent sections of this report and in Appendix B, specific outputs have been directed not only to industry and government organizations but to the general public as well.

Standards Development: In addition to their participation on various technical committees, as cited previously, Program personnel serve as participants and, in several cases, as chairperson on a variety of committees and sub-committees of agencies responsible for the development of standards for residential heating systems. These agencies include:

- Canadian General Standards Board (CGSB)
- Canadian Standards Association (CSA)
- Canadian Gas Association (CGA)
- Underwriters Laboratories of Canada (ULC)
-

In addition to their work related to the development of standards and codes for safe installation and operation, Program personnel have also been extensively involved in the development of techniques for defining seasonal appliance efficiency standards.

Further detail is provided in Section 3 and Appendix B.

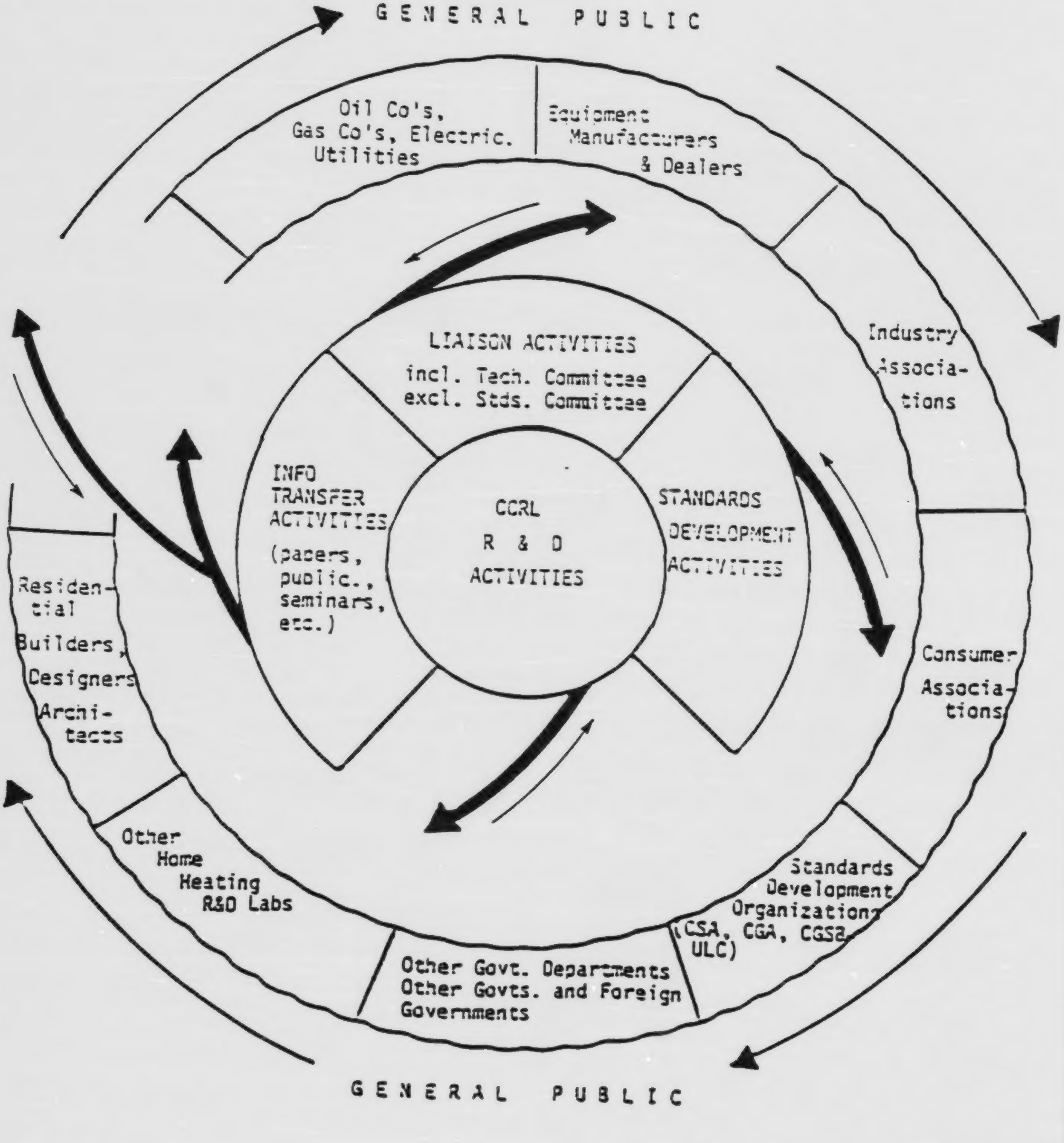
2.3.3 Program Linkages

As suggested in the preceding overview, the Program's various activities and outputs involve interaction with a wide variety of organizations and agencies. In broad terms, these organizations can be grouped into the following constituencies:

- Equipment Manufacturers
- Heating Industry Associations
- Consumer Associations
- Standards Development Organizations
- Federal Government Departments
- Provincial/Territorial Governments and Agencies
- Foreign Governments
- Other Research Laboratories
- Residential Builders, Designers, etc.
- Oil and Gas Companies and Utilities

Figure 2.4

CANMET/CCRL/Home HeatingProgram/"Wheel and Hub" Showing Major Linkages with Activities


GENERAL PUBLIC
Oil Co's, Gas Co's, Electric. Utilities
Equipment Manufacturers & Dealers
Industry Associations
Consumer Associations
Standards Development Organizations (CSA, CGA, CGSB, ULC)
Other Govt. Departments Other Govts. and Foreign Governments
Other Home Heating R&D Labs
Residential Builders, Designers Architects
LIAISON ACTIVITIES incl. Tech. Committee excl. Stds. Committee
INFO TRANSFER ACTIVITIES (papers, public., seminars, etc.)
STANDARDS DEVELOPMENT ACTIVITIES
CCRL R & D ACTIVITIES
GENERAL PUBLIC

In short, the program has established linkages, either directly or indirectly with virtually every major Canadian organization involved in the delivery of home heating products and services to Canadian consumers. These linkages have, of course, varied over the program's duration depending on the specific technology under development at any given time, and its stage of commercialization.

Figure 2.4 employs the concept of the "wheel and hub" to illustrate the variety of possible combinations of linkages that exist between the major program activity areas and constituencies. For graphic simplicity, the schematic does not attempt to show all of the possible combinations; rather, the schematic illustrates that the Program's approach to achieving its mandate includes extensive interaction with a diverse collection of organizations. There is not one simple, linear relationship which is, in and of itself, capable of achieving the desired results.

2.3.4 Program Resources

The FFH Program receives funding from both CANMET and, beginning in 1976, from PERD, the Panel on Energy Research and Development. Figure 2.5 provides a breakdown of person-years (PYs) and contract dollars allocated to the program over its duration.

As shown in Figure 2.5, the FFH Program began in 1971 with a CANMET resource allocation of 2 person-years. Following the start-up of PERD in 1976, PERD funding increased the FFH Program's annual resource allocation to 3.5 person-years as well as providing approximately $100,000 annually for external contracts. In 1981, following the federal government's implementation of the National Energy Program, PERD support of the FFH Program was further increased, bringing the total annual resources available to the Program to its current level of 7 person-years and approximately $200,000 for external contracts.

FIGURE 2.5
ANNUAL PROGRAM RESOURCE ALLOCATION
- BY PERIOD AND SOURCE -
1971 to present

	Period		
	1971-75	1976-80	1981-Present
. Person-years	2	3.5	7
. Annual External Contract $	0	$100,000	$200,000

SECTION 3
PROGRAM ACTIVITIES AND OUTPUTS BY TIME PERIOD AND CONSTITUENCY

3.1 INTRODUCTION

This Section presents a more detailed review of specific Program activities and outputs that have taken place over the period 1971 to present. The review is presented in two sections:

- In Section 3.2, Program activities and outputs are presented chronologically not only to illustrate the specific activities themselves, but also to demonstrate their relationship to the (then) prevailing national energy context and home heating issues.
- Section 3.3 provides further documentation by identifying specific Program inputs to each of the previously identified industry constituencies.

3.2 CHRONOLOGICAL OVERVIEW OF PROGRAM ACTIVITIES AND OUTPUTS

3.2.1 Introduction

It is impossible to fully document each and every Program activity that has occurred over the period 1971 to the present; nonetheless, this section attempts to outline both the nature and the evolution of specific program activities. Because any program's activities are significantly influenced by the broader context in which they operate, a brief review of the (then) prevailing national energy context and the key issues confronting the home heating industry are also presented.

For the purposes of this overview, 5 periods, defined by national energy events, have been chosen. They are:

- 1971-73 - The period covering the program's initiation to the onset of the 1973 OPEC oil embargo.
- 1974-77 - The early stages of the "oil crisis".
- 1978-80 - The late stages of the "oil crisis", including the 1979 Iranian oil boycott.
- 1980-85 - The period in which the National Energy Program (NEP) was in place.
- 1985-present - The period following the change of the federal government and the subsequent dismantling of the NEP.

The following pages provide an outline of the national energy context, the issues and the major Program activities which occurred in each of the 5 time periods indicated above. The selected transition periods are, of course, only approximate, but they are sufficiently accurate for the present purpose.

TIME PERIOD 1
PRE-OIL CRISIS
1971 TO 1973

National Context

- The OPEC oil embargo had not yet occurred; No. 2 fuel oil was the dominant source of fuel for residential heating with approximately 57% of the national residential market share (households), while natural gas, electricity and wood accounted for about 32%, 6% and 4%, respectively.

- In 1973, the oil suppliers dropped the prepaid annual furnace service charge from the fuel price. Formerly a "hidden" charge of about $0.01/gallon had been levied to users in return for automatic annual furnace maintenance; thereafter, furnace maintenance was treated as a distinct service, to be purchased separately. As a consequence, homeowners began to demand an improved level of furnace service from their oil company, if they were now to pay for this formerly "free" service.

Issues

The major focus of this period was on reducing oil furnace pollutant emissions and on reducing burner noise problems.

Program Activities/Outputs

The FFH Program was involved in extensive oil burner evaluations. Specific technologies were investigated through lab and field trials and included:

- high/low speed motors
- vane swirlers
- development work on the blue flame burner
- performance testing of the flame retention head burner

The results of these tests identified and documented the potential efficiency gains that could be achieved in residential space heating systems, and provided important input to early policy formulation.

TIME PERIOD 2
EARLY OIL CRISIS
1974 TO 1977

National Context

- The OPEC oil embargo had occurred in the fall of 1973; fuel oil prices increased dramatically; oil import dependent provinces, in particular, began to demand federal oil price subsidies/assistance.

- The federal government's response to the oil embargo included the formation of the Office of Energy Conservation and the development of federal energy conservation policy and programs.

- Fuel oil remained the dominant source of fuel for residential space heating but residential use of natural gas and wood was increasing. The Canadian Wood Energy Institute (CWEI) was formed in 1977.

Issues

The focus of residential heating system R&D shifted to include a new emphasis on efficiency with respect to both the "hardware" and servicing.

Program Activities/Outputs

A) Oil

- The FFH Program engaged in extensive lab and field trials of furnace efficiency measures such as:
    - furnace set-back
    - delayed action solenoid
    - retention head burner
    - reduced firing rate

- Field trials were particularly important as they provided critical baseline performance data enabling measurement, documentation and comparison of the effectiveness of practical furnace efficiency and retrofit measures gained in a "real-life" setting. These latter points of "real life" and "practical" R&D results did (and still do) much to reinforce the credibility of the Program's results. (This aspect is discussed further in Section 4.)

- Analysis of the performance of double-wall prefabricated metal chimneys for oil-fired residential heating systems.

- In addition to its emphasis on the above "hardware" efficiency measures, the Program's R&D experience also identified the importance of proper furnace tuning and maintenance to overall heating system performance. It became evident not only to Program personnel but also to industry and government that conventional furnace maintenance practices required substantial upgrading if more energy efficient furnace performance was to be realized.

Time Period 2 (cont'd): Early Oil Crisis - 1974 to 1977

Again, the credibility of the Program's R&D results were enhanced because of the heavy emphasis on field experience, enabling Program personnel to be influential among their industry and government colleagues.

. An important Program activity in the period was, therefore, the development and delivery of furnace servicing training materials to the furnace servicing industry, in cooperation with community college networks, industry and government. As discussed in further detail in Section 3.3, this activity resulted in the preparation of numerous technical papers, publications and seminars.

. Preparation and publication, with the Office of Energy Conservation, of *The Billpayer's Guide to Furnace Servicing*, a consumer booklet which clearly specified what the homeowner should expect and demand from furnace servicemen.

. Commercial use of the above measures was preceded by the development of new codes and standards, an activity in which Program personnel were extensively involved.

B) Alternate Heating Fuels

. Finally, throughout the period, the Program undertook analysis of the effects of fuel oil additives and fuel aromatic content on burner performance. Methanol as a heating fuel substitute was also evaluated.

TIME PERIOD 3
LATE OIL CRISIS
1978 TO 1980

National Context

- In addition to furnace performance, there was growing federal government emphasis on residential building envelope retrofit measures as a means of reducing space heating requirements; the Canadian Home Insulation Program (CHIP) was established.
- There was growing interest in the possibility of a national oil furnace retrofit program.
- The Iranian oil boycott in 1979 resulted in further sharp increases in fuel oil prices, and firmly convinced the Canadian energy-related industry that high oil prices and oil supply interruptions were not passing phenomena.
- There was growing interest in alternative heating fuels.

Issues

- The need for upgrading the oil furnace servicing industry's skills became more important, as did the need to establish CSA certification of oil furnace retrofit kits.
- Wood heating safety, efficiency and emissions became important issues of concern for both government and consumers and for the fledgling wood heating industry that existed at the time.
- Given the shift to natural gas heating that was occurring, increased emphasis was placed on determining the efficiency of existing gas furnaces.

Program Activities and Outputs

A) Oil

- Development and manufacture of an oil burner retrofit kit in conjunction with Aero Environmental Ltd.
- Technology transfer to the oil heating servicing and equipment industry.
- Certification by CSA of 6 retrofit kits for oil furnaces.
- Extensive interactions with provincial government departments concerning safety and performance issues related to oil furnace retrofit (to ensure their participation in the potential national oil furnace retrofit program).
- Extensive technical support to the pilot residential oil retrofit program carried out in Prince Edward Island.

Time Period 3 (cont'd): Late Oil Crisis - 1978 to 1980

B) Gas

- Performance testing of conventional gas furnaces began; opportunities for potential efficiency improvements for new furnaces and for retrofit applications were identified, including the condensing flue retrofit.

C) Wood

- Extensive lab and field testing of the various wood stove designs then on the market.
- Development of test procedures to measure wood stove efficiency and emissions.
- Extensive involvement via the Canadian Wood Energy Institute (CWEI), with the development of the fledgling wood energy industry.

D) Alternate Heating Fuels

- Performance testing of methanol fired furnaces.

TIME PERIOD 4
NATIONAL ENERGY PROGRAM
1981 TO 1985

National Energy Context

- The National Energy Program (NEP) was announced in October 1980, bringing with it a strong federal government "off-oil" policy focus and increased emphasis on alternative heating fuels; federal government plans for a national oil retrofit program were dropped as a result.

- The Canadian Oil Substitution Program (COSP), a major component of the NEP's off-oil thrust, took effect and gas, electricity and wood began to capture increased portions of the residential heating market from oil as a result of the grants provided. Market competition among fuels and electricity increased dramatically, particularly in Ontario.

- In 1982, the major oil companies withdrew participation from all technical and standards development committees; the independent home oil heating sector was particularly adversely affected; The Home Energy Group, an association of independent Ontario oil furnace manufacturers and fuel oil retailers was formed.

- The Ontario Natural Gas Association (ONGA) underwent a major reorganization; additional resources were devoted to a more aggressive, proactive marketing and member support strategy.

- Expansion of the natural gas supply network increased substantially with the federal government's financial support.

- The R-2000 housing program was announced; targets for reducing heating loads by 85% through super high insulation and reduced air exchange rates were set.

Issues

- Market competition lead to increasing concerns about the validity of claims made by home heating product and fuel suppliers regarding the performance and cost savings benefits of their respective products.

- Continued emphasis on safety, emissions and efficiency of wood heating appliances.

- Expanded emphasis on new and retrofit gas furnace technology.

- Increased emphasis on the impacts of super-tight, energy-efficient housing on furnace combustion air and venting requirements (indoor air quality).

- Emergence of house-as-a-system concept.

Time Period 4 (cont'd): National Energy Program - 1981 to 1985

Program Activities/Outputs

A) Oil

- Promotion of oil furnace retrofit kit, consisting of retention head, reduced nozzle size and delayed action solenoid.
- Preliminary design work on condensing oil furnaces.
- Lab evaluations of ultrasonic modulating oil burners.
- Ongoing technical and moral support to independent oil heating industry.
- Development work on techniques to measure seasonal furnace efficiency for standards development.

B) Gas

- Lab and field trials of retrofit condensing gas furnaces.
- Development of plastic condensing furnace.
- Lab evaluation of advanced heat exchangers for gas furnaces and boilers.
- Development of prototype retrofit induced draft fan package.
- Field testing of advanced pulse combustion furnace.
- Field testing and commercialization of condensing flue retrofit package.

C) Wood

- Publication of reports on wood stove design and performance, including certification of wood stoves for COSP eligibility.
- Performance assessment of add-on wood furnaces.
- Wood combustion analysis and advanced combustion chamber design work.
- Development of efficiency and emissions standards for wood appliances.
- Field trials to determine the effects of catalysts and advanced designs on wood heating combustion efficiency and emissions.
- Assessment of efficiency potential of fireplace inserts.

D) Air Quality and Venting Systems

- Development of design parameters for furnace air supply and gas exhaust in energy-efficient housing.

Time Period 4 (cont'd): National Energy Program 1981 to 1985

- Assessment of hazardous heating and ventilating conditions in housing.

E) Alternate Heating Fuels

- Analysis of effects of middle distillate heating fuels on oil burner combustion.
- Analysis of the potential for vegetable oils as a domestic heating fuel.
- Development of an oil furnace retrofit design for methanol combustion.

TIME PERIOD 5
POST NEP
1985 TO PRESENT

National Context

- General reduced federal role in promotion of energy conservation and alternate heating fuels, and reduced "off-oil" focus: NEP dismantling, including termination of COSP and CHIP grants; extension of R-2000 housing program, in conjunction with the Canadian Home Builders Association (CHBA).

- Significant drop in world oil prices; return to more neutral government policy regarding fuel choice.

- Greater federal government emphasis on marketplace determination of energy options.

- Decline of oil's share of the national residential heating market levels off at about 22% (households). Natural gas, electricity and wood reach a market share of about 44%, 28% and 5%, respectively.

Issues

- Continued emphasis on optimization of heating systems for all fuels.

- Increased emphasis on dual fuel and hybrid (space and hot water) heating systems, compatible with declining heating requirements of the new, more energy efficient housing.

- Continued emphasis on indoor air quality concerns--leakage of combustion products as well as other indoor pollutants--in both new and existing housing, but particularly in new energy-efficient designs.

- Growing emphasis on development of minimum seasonal efficiency standards for heating appliances.

Program Activities/Outputs

A) Oil

- Development and testing of an advanced efficiency hybrid oil furnace and water heater

- Continuing development of techniques for measuring seasonal oil furnace efficiencies.

B) Gas

- Development and testing of advanced plastic heat exchangers.

- Continued testing and certification of gas furnace condensing flue retrofit kit.

Time Period 5 (cont'd): Post NEP 1985 to Present

- Field testing and performance assessment of advanced efficiency gas furnaces.

C) Wood

- Field testing to determine effects of catalysts and advanced non-catalyst designs on wood burning appliance efficiency and emissions.

D) Air Quality and Venting Systems

- Ongoing testing and assessment of affect of combustion appliances on indoor air quality including:
  - assessment of potential for backdrafting in problem housing
  - field evaluations of residential ventilation system guidelines
  - determination of thermodynamics of vents and flues.

E) Alternate Heating Fuels

- Preparation of updated "*Combustion Handbook for Canadian Fuels*".

3.3 OVERVIEW OF CCRL ACTIVITIES BY CONSTITUENCY

This section provides an overview of the Program's involvement with, and impact on, firms and organizations representing the various home heating industry constituencies, as previously identified in Section 2.3.3. As in the preceding section, the reader is cautioned that the CCRL inputs cited herein are not exhaustive. Rather, they represent those identified within the project interviews; the scope of this study was never intended to encompass all contacts and inputs. This section provides:

- a brief description of each major constituency, including its overall role or mandate within the Canadian home heating industry
- a brief review of the specific inputs provided by CCRL to each, including documentation of the degree of reported CCRL influence and overall industry impacts reported by the constituency.

Due to the relatively high degree of overlap among both the mandates and activities of some of the previously cited constituencies, the previously identified list of constituencies has been aggregated somewhat. Thus, for the purposes of this section, some of the individual constituencies are discussed jointly, as appropriate and as indicated in each subsection.

3.3.1 EQUIPMENT MANUFACTURERS

Introduction

Based on data from Statistics Canada and industry sales reports, the total sales of residential fossil fuel space heating furnaces in 1985 were estimated to be about 160,000 units.

The selected interview sample included 14 Canadian firms involved in the manufacture and sale of residential oil burners, oil and gas furnaces/boilers and wood furnaces/stoves. Together, the selected sample represented over 70% of Canada's annual furnace production capacity. Annual sales data for wood stoves were not available; however, the selected sample represented an annual production capacity in 1986 of over 25,000 units and accounted for a significant market share.

In broad terms, the furnace manufacturing sector is composed of a mixture of larger firms having a national market orientation and smaller firms serving predominantly regional markets. Wood stove manufacturers tend to be either large volume, low price producers or small volume, premium price producers.

All firms reported some level of in-house R&D capability although this capability was unevenly distributed. In general, the larger furnace manufacturers and the producers of premium quality wood stoves reported greater resource allocation to new and improved product development. The most frequently cited factors defining their R&D priorities were:

- Declining thermal load in residential units, thus requiring the development of lower heat output appliances.

- Market demand for more efficient appliances (lower heating costs) and new features, e.g., convenience and aesthetic factors for wood stoves.

- Market competition among heating product producers, thus requiring continued product improvements to retain market share.

- Desire to ensure that product lines conform to new performance standards under development. In this respect, the legislation of minimum efficiency standards in the U.S., together with related testing procedure and standards development work in Canada, has convinced many manufacturers that soon inefficient product lines will not be marketable in Canada either.

As is described more fully in the following Section 4, over the program's duration, there have been very substantial improvements in the fuel efficiency, safety and emission levels of Canadian home heating appliances for all fuels and for both new and retrofit applications. While the description of these improvements is left to Section 4, the following discussion indicates the types of inputs provided by CCRL and the degree of reported CCRL influence.

CCRL Inputs and Reported Influences

CCRL's direct support to equipment manufacturers can be categorized into 3 primary types:

- Direct financial support for product development and testing
- Provision of technical assistance
- Provision of general information and referrals

Most reported contacts take place via telephone and in-person meetings, particularly during participation in conferences, seminars and standards development committees.

The most frequently reported CCRL input (9 of 14 firms) was technical and general information. Specific examples cited included:

- concept brainstorming
- provision of test or product performance results
- specific problem resolution
- review of CCRL prepared and distributed technical publications
- referral to other appropriate agencies, individuals or technical documents

For many of these firms, CCRL serves as a highly respected impartial and "neutral" source of "second opinion", confirming or providing suggested amendments to the product development initiatives of individual firms as well as providing an efficient and economical means for firms (particularly smaller ones) to gain an overview of new product developments occurring throughout the industry.

Only 2 of the manufacturing firms interviewed had received direct financial support from CCRL. They were:

Aero Environmental Ltd. - CCRL provided financial support as well as technical and product testing and certification assistance to Aero related to development of the retrofit retention head oil burner. In this case, CCRL came to Aero with the technical concept and assisted them financially and technically throughout all phases of the product's commercialization. This product, developed largely in anticipation (then) of a national oil retrofit program, would not have been manufactured by Aero without CCRL's involvement. Though certified and available on the market since the early 80's, sales of the product have been limited. Aero reported that most consumers prefer a new retention head burner to a retrofitted one. Thus, the overall impact on consumers has been very limited.

Clare Brothers - CCRL provided similar financial and technical assistance to Clare Brothers for the development of the retrofit condensing gas furnace. Again, Clare Brothers reported that they might have gone ahead with the retrofit kit on their own initiative, but probably would have given up when problems with certification arose. With CCRL's assistance, the retrofit kit is now certified and commercially available. However, current sales have been only a few hundred per year since its' introduction in 1985. Thus the overall impact on consumers has been limited.

CCRL has also provided financial and technical assistance to Clare Brothers, in association with Aero, for the development of an advanced efficiency oil furnace and water heater. The product is currently at the testing stage; without CCRL's involvement, Clare indicated that they would not have pursued product development at this time.

In addition to the above firms, CCRL has also provided direct financial support to Consumer's Gas for the purposes of new product development. Although Consumer's Gas is not an equipment manufacturer per se, it is Canada's largest gas utility and has a dedicated technology development department. New products developed by Consumer's Gas are made available to existing manufacturers for subsequent production; consequently, their involvement with CCRL is similar to that with equipment manufacturers.

CCRL financial support to Consumer's Gas has been for:

- development of a plastic heat exchanger for condensing gas furnaces, and
- field testing of high efficiency gas furnaces

In addition to financial assistance to Consumer's Gas for development of the plastic heat exchanger, CCRL provided technical and project conceptualization input. Without CCRL's financial and technical support, Consumer's Gas reported that the product would not have been developed. The new heat exchanger, which offers significant cost advantages over the new alloy and steel exchangers now in use in condensing furnaces, is in the final stages of certification.

CCRL provided financial and technical support to Consumer's Gas for the field testing of various brands of high efficiency gas furnaces. The technical support provided by CCRL focused on the development of test methods and data collection procedures. The project provided valuable information to manufacturers, government agencies, contractors, etc. on furnace performance, reliability and potential problem areas. For example, some units which had performed reliably in the lab failed under actual field conditions. Without CCRL's support, Consumer's Gas reported that the product testing would have been much less comprehensive and the results would not have been as widely communicated.

As is more fully reported in Section 4, approximately 50% of the firms interviewed reported that CCRL input was either very influential or moderately influential to their product development decisions. Further, several of those firms not reporting any direct CCRL influence on their product development decisions, did report that they had been indirectly influenced by the development of new product standards and other industry generated technical materials, areas where CCRL has provided substantial input.

3.3.2 INDUSTRY ASSOCIATIONS

Introduction

The following industry associations were interviewed:

- Ontario Natural Gas Association (ONGA)
- Canadian Wood Energy Institute (CWEI)
- Home Energy Group (HEG)
- Heating, Refrigeration and Air Conditioning Institute (HRAI)
- Canadian Home Builders Association (CHBA)

In general, each of the above associations has a mandate to represent the interests of its members to government policy makers, consumers and other special interest groups. Consequently, related activities range from government lobbying and participation on technical or standards development committees, to joint marketing initiatives and technical training for members. Together, the above associations represent the interests of more than 6,000 small- and medium-sized Canadian firms involved in the manufacturing, sales, design, installation and servicing of home heating products and systems. Figure 3.1 (overleaf) presents a summary of each association's membership and mandate.

As implied by the mandates and memberships shown in Figure 3.1, the primary purpose of these associations is the continued survival and development of the predominantly small- and medium-sized firms which they represent. In view of the very significant industry turmoil experienced as a result of the energy crisis, survival has meant the ability to effectively keep pace with the rapid changes in home heating technologies and inter-fuel competition. Thus, in addition to providing a voice to government, these associations have also undertaken an important technology transfer role to their members. One of the consequences of the turmoil mentioned above, has been increased industry competition to provide consumers with safe, energy- efficient heating products and fuels which are cost competitive with other alternatives available. This, in turn, requires not only improved products and services, but also more knowledgeable design, sales, and service personnel.

These associations' member firms generally lack the resources to individually keep abreast of new technology developments. Thus, a major contribution of the associations has been the assembly and interpretation of scientific and technical information and the transfer of this knowledge to member firms, in a format which is both comprehensible and practical to them.

CCRL Inputs and Reported Influence

The most valuable CCRL input, consistently identified by each of the above associations was the provision of credible, impartial technical and scientific knowledge. This input has been provided by means of telephone consultations, seminar and conference presentations, participation on technical committees and through assistance in the preparation of training and education materials and courses. Figure 3.2 provides a partial listing of reported training materials and course participation, in which CCRL has provided substantial input. Further examples of specific CCRL inputs to each association, as well as the reported degree of CCRL influence on each, is provided in Figure 3.3. It should be noted that other industry associations such as the Canadian Gas Association and the Ontario Petroleum Association were also interviewed, but because of their broader involvement, they are referred to elsewhere.

FIGURE 3.1
HEATING INDUSTRY ASSOCIATIONS
- MEMBERSHIP AND MANDATE -

Association	Membership	Mandate/Objectives
1. Ontario Natural Gas Association (ONGA)	. Approximately 80 Ontario members drawn from all aspects of gas industry including utilities, equipment manufacturers, gas pipeline companies, consultants etc.	. Promote development and growth of natural gas industry . Formulation and presentation of industry positions with government media and public interest groups
2. Canadian Wood Energy Institute (CWEI)	. Approximately 250 members including manufacturers, retailers, chimney sweeps, installers, and other related associations such as the Biomass Institute, Forestry Associations, etc.	. A trade association able to represent the interests of the industry as a whole to government . Promotion of solid fuel heating as a safe energy source
3. Home Energy Group (HEG)	. Independent Ontario fuel oil retailers and oil furnace and burner manufacturers	. Improved business environment for fuel oil distributors and equipment manufacturers . Achieve fuel neutrality in government policy and programs
4. Heating, Refrigeration and Air Conditioning Institute (HRAI)	. Approximately 700 HVAC contractors, distributors, suppliers and manufacturers	. To represent and further develop the industry in Canada . To influence technical, government and other agencies which affect the industry on a national or regional level.

FIGURE 3.1
HEATING INDUSTRY ASSOCIATIONS
- MEMBERSHIP AND MANDATE -
Cont'd

Association	Membership	Mandate/Objectives
5. Canadian Home Builders Association (CHBA)	. Approximately 5000 members--small and medium size firms plus subcontractor trades and related lending/mortgage institutions . Also affiliated with Quebec chapter (APCHQ) housing--additional 5000 members	. To represent the interests of medium and small house builders in Canada

FIGURE 3.2
CCRL ASSISTED TRAINING MATERIALS/AUDIENCE

Association	Materials	Audience
Canadian Home Builders Association (CHBA)	. R-2000 Training workshops	. 3000 members have completed course
Home Energy Group (HEG)	. Oil heating, training packages	. distributed to HEG members
Canadian Wood Energy Institute (CWEI)	. Installation, operation and maintenance of wood burning appliances	. approximately 1000 trades persons have completed course
Heating, Refrigeration and Air Conditioning Institute (HRAI)	. Training materials on efficiency, air quality, house as a system etc.	. members

FIGURE 3.3
CCRL INPUTS AND REPORTED INFLUENCE
- INDUSTRY ASSOCIATIONS -

Association	Selected CCRL Inputs, as Reported	Degree of Reported Influence
1. Home Energy Group (HEG)	. Supportive scientific information to justify formation of HEG and push for more neutral government treatment of fuel oil . Evaluation of new and emerging technologies . Direct input to member training materials	. Very High . Would not exist without CCRL
2. Canadian Wood Energy Institute (CWEI)	. Together with ULC, CSA and EMR provided invaluable technical and leadership inputs; industry credibility problems of late 70's might not have been overcome otherwise . Input to CSA B-365 and CSA B415 standards very influential on wood industry's development and public credibility . More influential than CWEI re: inclusion of wood systems in COSP which gave industry a major sales boost and visibility . Direct input to training materials	. 1977 to 82 - High . 1982 to Present - Low . Significant player in Industry's development;
3. Heating, Refrigeration and Air Conditioning Institute (HRAI)	. Technical input on combustion backdrafting and chimneys . Provision of credible data on product efficiencies which are used in consumer promotions	. Moderate . Would need to re-create an equivalent impartial body, if CCRL did not exist
4. Canadian Home Builders Association (CHBA)	. Technical understanding of performance of combustion equipment, proper system design etc. (house as a system) in low energy housing . Potential problem identification and practical suggestions for resolution . Participation on Technical and Research R-2000 Committees	. Moderate . Would need to re-create an equivalent impartial body if CCRL did not exist
5. Ontario Natural Gas Association (ONGA)	. Objective evaluation of new products . Technical input on air quality and furnace technology efficiency issues	. Very High . Well integrated with government and industry . Provides neutrality in an area having lots of vested interests

3.3.3 FEDERAL AND PROVINCIAL/TERRITORIAL GOVERNMENT DEPARTMENTS AND AGENCIES

Introduction

The federal and provincial governments are responsible for the development and implementation of a broad range of energy policies and programs. To obtain a representative range of views on the role and influence of CCRL, six specific areas were investigated. They were:

- Policy and Program Development
- Research and Development
- Consumer Information and Education
- Technology Transfer
- Consumer Protection
- Provincial/Territorial Government Programs

Figure 3.4 provides a list of the federal, provincial and territorial government departments (and their programs) which were included in the interview sample. A summary of specific program mandates is also provided to give some indication of the technology areas and target groups involved. Dates shown in brackets indicate the approximate period in which the program was, or has been, in effect.

CCRL Inputs and Influence

Because of its technical expertise and experience with fossil fuel heating systems, combined with its knowledge of the industry and its neutrality, CCRL is often called upon to assist government departments in the definition and implementation of programs involving residential heating systems. Figure 3.5 provides more specific examples of CCRL inputs with reference to the 6 areas noted above.

As noted in Figure 3.5, CCRL has played a very influential role within each of the policy and program areas, including both federal and provincial/territorial agencies. However, CCRL has had considerably more contact with federal departments than with the provincial/territorial counterparts.

In addition to Canadian government departments, CCRL has also had involvements with a number of related U.S. departments. Unfortunately, the key U.S. government interviewee was not available during the project's interview phase. However, partial coverage of CCRL involvement with U.S. agencies is included in Section 3.3.5.

FIGURE 3.4
FEDERAL AND PROVINCIAL/TERRITORIAL GOVERNMENT DEPARTMENTS AND MANDATE

Government Department/Program	Mandate
Federal Government: Policy and Program Development	
1. Office of Energy Conservation (1974-1978)	. Development of federal policy and programs to promote energy conservation
2. Panel on Energy Research and Development, EMR (PERD) (1974 to present)	. To accelerate the development of a broad energy science and technology base in Canada in support of a diversified energy economy and long term independence from non-renewables
3. Research Division, CMHC (1983 to present)	. To identify housing performance problems; co-ordinate R&D to develop solutions; and to assist in the communication of solutions
Federal Government: Consumer Education	
4. Home Energy Programs, EMR (1974 to present)	. To provide consumer advice and assistance related to residential energy management
5. Conservation and Renewable Energy Office (CREO), P.E.I. (1981 to present)	. To provide consumer advice and regional implementation of federal energy programs

FIGURE 3.4
FEDERAL AND PROVINCIAL/TERRITORIAL GOVERNMENT DEPARTMENTS AND MANDATE
cont'd

Government Department/Program	Mandate
Federal Government: Technology Transfer	
6. R-2000 Program, EMR (1978 to present)	. Promotion of R-2000 housing designs to consumers; development of industry capability to provide R-2000 housing, and; identification and resolution of issues
7. Renewable Energy Branch, EMR - Biomass Division (1980 to present)	. To promote the increased substitution of biomass for oil
Federal Government: Consumer Protection	
8. Consumer Protection Branch, CAC (1974 to present)	. To enforce Competition Act, including misleading advertising or product performance misrepresentation; to make sure market information is fair and reasonable
Provincial/Territorial Governments and Agencies	
9. Energy and Minerals Department, P.E.I. (1975-81)	. To promote the adoption of energy conservation measures and the development of renewable energy sources
10. Energy and Mines, Government of Yukon (1980 to present)	. To reduce the burden of high energy costs on Yukon residents and to reduce the outflow of dollars through improved energy efficiency and substitution of indigenous resources for imported fuels

FIGURE 3.4
FEDERAL AND PROVINCIAL/TERRITORIAL GOVERNMENT DEPARTMENTS AND MANDATE
cont'd

Government Department/Program	Mandate
11. Newfoundland Department of Energy & Mines (1975 to present)	. Technology transfer to the public; professionals and trades related to improved safety and efficiency in home heating
12. Ontario Ministry of Energy - Conventional Fuels Program (to 1982)	. To ensure balanced public representation of competing claims of different fuels
13. Provincial Community Colleges . Ontario - Heating Programs . Quebec - Heating Programs	. Training for students and licensed heating mechanics in oil and gas furnace installation and servicing

FIGURE 3.5
CCRL INPUTS AND REPORTED INFLUENCE
- FEDERAL, PROVINCIAL AND TERRITORIAL GOVERNMENT DEPARTMENTS -

Area	CCRL Inputs	Degree of Influence Reported
1. Federal Policy and Program Development	. Technical Input re: furnace efficiency potential	. Very influential; provided credibility re: claims of savings potential
2. Federal R&D	. As member of PERD Committee and Building Energy Conservation subcommittee (BECS) provides input to R&D directions and priorities;	. Very influential, particularly as a result of direct field experience and wide government/industry linkages
	. Provides combustion expertise to CMHC's work on "house-as-a-system", ensures validity of R&D assumptions; provides credibility to CMHC's interaction with other agencies	. Critical; would have had to recreate CCRL's body of knowledge otherwise
3. Federal, Consumer Education Programs	. Provided technical input, text review and photographs to heating system portion of following EMR publications - 100 Ways - distribution of over 3 million copies - Bill Payer's Guide - distribution of over 2 million copies	. Critical; only body at the time with the technical capability
	. Provided technical training to EMR staff - 250 summer Job/Core Eneraction Program staff trained re: furnace efficiency testing	. Critical; over 25,000 households received furnace efficiency tests
	. Provided periodic technology update seminars for Enersave/Heatline staff; on-going technical review/input to fact sheets, etc.	. Moderate

FIGURE 3.5 (cont.)
CCRL INPUTS AND REPORTED INFLUENCE
- FEDERAL, PROVINCIAL AND TERRITORIAL GOVERNMENT DEPARTMENTS -

Area	CCRL Inputs	Degree of Influence Reported
4. Technology Transfer	. Provided original technical text for EMR industry publication: Oil Furnace Serviceman's Guide	. Critical; only body at the time with the capability to prepare text
	. Provided technical input to R-2000 Program related to impact of combustion appliances on R-2000 designs, issue identification and R&D requirements	. Influential
	. Provision of technical input to standards development, facilitating technology transfer to biomass industry	. Influential
5. Federal Consumer Protection	. Provides neutral expert opinion and references to other sources of expertise, enabling CCA to ensure that unsubstantiated and illegitimate energy product or fuel claims are not being made to consumers	. Modest; saves CCA time and resources, when relevant consumer complaints arise
6. Provincial/Territorial Governments and Agencies - P.E.I.	. Provided broad technical support to PEI. government on oil furnace efficiency and pilot oil retrofit program including: - training in furnace efficiency testing procedures - 30,000 homes reached, as part of Enersave program - developed burner servicing and retrofit training course - 65 servicemen (50% of PEI industry) completed course - assisted in pilot oil retrofit program - 200 retrofits completed	. Critical; P.E.I. did not have the resources at the time to do on their own; CCRL very influential in overcoming service industry's skepticisms re: potential savings
- Yukon	. Provided general combustion information to Yukon government including talks to industry	. Influential; helped gain industry support for furnace efficiency measures

FIGURE 3.5 (cont.)
CCRL INPUTS AND REPORTED INFLUENCE
- FEDERAL, PROVINCIAL AND TERRITORIAL GOVERNMENT DEPARTMENTS -

Area	CCRL Inputs	Degree of Influence Reported
- Yukon (cont.)	. CCRL data on potential furnace efficiency improvements have enabled Yukon government to incorporate furnace testing/tuning as a mandatory area of household energy analysis within their residential energy conservation loan program - approx 300 homes/yr. since early 1986	. Very Influential; without available performance data, unlikely that furnace testing would be a mandatory program element
- Newfoundland	. Provide general technical input and data to Newfoundland government publications on home heating	. Moderate; valuable input but infrequent contact
7. Community Colleges		
- Ontario and Quebec	. CCRL initiated the concept of upgrading furnace service skills and provided initial course materials, instructor training and assistance in equipment acquisition	. Very influential; probably would not have been able to do on their own or would have been much delayed; CCRL's intervention was key to the growth of these training programs and expansion of scope of course content both for students as well as tradesmen

3.3.4 STANDARDS WRITING ORGANIZATIONS

Introduction

Four organizations are accredited in Canada to write standards for product specifications, performance, and installation:

Canadian Standards Association (CSA)
Canadian Gas Association (CGA)
Canadian General Standards Board (CGSB)
Underwriters Laboratory of Canada (ULC)

All operate on a not-for-profit basis under accreditation from the Standards Council of Canada. Standards must be developed by voluntary committees with equal representation from manufacturers, users, regulators and general interest parties. There are some variations of this requirement. CSA, for example, maintains an ongoing steering committee for each major product area and forms technical committees to develop the actual standards. At CGSB, committees have both voting members and observers, which allows a larger number of general interest parties to contribute.

Committee members are usually drawn from: the manufacturers of the products for which standards are being developed; the wholesalers, retailers, installers, and users (consumers) of the products; any government agencies or utilities that regulate its use; and general interest parties such as research organizations. It is usually the manufacturers who initiate the development of a new standard and who bear the cost of its development. This is primarily because it is in their interest to have consistent quality and performance in the market. In some cases, regulators such as utilities or government agencies take a more active role to encourage the development of an embryonic industry or to support a specific government policy. In home heating, examples of this proactive approach include the development of standards for wood stoves and solar water heaters.

In all cases, however, the voluntary committee system is used. If any laboratory or field testing is needed during the development of the standards, small task groups are usually formed to plan the work. The work is then carried out by an industry, government, or private research laboratory, especially one with expertise in the field (e.g., CCRL), and results are reported back to the committee. The committee structure also acts as an important forum at which manufacturers, users, regulators and technical experts can openly discuss innovations and problems.

Each of the four standards writing organizations also offers certification services. If an industry, utility or government requires that users be informed as to which products meet a given standard, the standards organization will arrange to compare and test each product on the market against the standard and publish a "list of certified products" that is, all those that meet the standard.

Some standards developed by the industrial agencies are accepted and published as Canadian Standards by the Standards Council of Canada.

In a few cases, a government will legislate that a product cannot be sold or installed unless it meets a standard or meets a minimum level of performance when tested according to a protocol included in a standard. All electrical products, for example, must meet electrical safety standards and be CSA certified. Electric water heaters must deliver a minimum quantity of hot water and achieve a minimum level of efficiency.

CCRL's Role and Reported Influence

CCRL personnel sit on the following standards committees concerned with fossil fuel heating systems:

Canadian Gas Association (CGA):

- Sub-committee on Seasonal Efficiency of Central Gas Furnace Standards Committee

Canadian Standards Association (CSA):

- Fire Safety and Combustion
  - Steering Committee on Fire Safety and Combustion
  - Committee on Oil Heating Systems
  - Retrofit Flame Retention Heads
  - Sub-committee on Chimney Dampers
  - Committee on Wood Fired Appliances
  - CSA/ULC Committee on Solid Fuel Fired Space Heaters
  - Add-on Wood Furnaces
  - Committee on Masonry Chimneys and Fireplaces
  - Installation Code for Solid Fuel Appliances
  - Emissions and Efficiency of Solid Fuel Appliances
- Buildings and Building Products
  - Committee on Energy Evaluation of Homes
  - Sub-committee on Analytical Techniques for Housing
  - Sub-committee on Measurement Techniques
  - Executive Management Committee on Venting Systems
  - Task Group on Controlled Ventilation in Housing
  - Committee on Ventilation in New Housing

Underwriters Laboratory of Canada (ULC)

Canadian General Standards Board (CGSB):

- Combustion Venting Requirements Committee
- Petroleum Test Methods Committee
- Middle Distillates Fuels Committee

The specific CCRL inputs reported by each organization are similar. They include:

- Knowledge of technology and testing procedures and results.

- The ability to carry out independent research to resolve problems and questions, and to confirm test procedures.

- Capability and initiative to address issues that industry, on its own, is not willing or able to investigate; for example, CCRL was able to quickly provide information on the relative efficiencies, costs and safety aspects of different combustion equipment, including air requirements, to CSA.

- Knowledge of, and ability to evaluate, U.S. experience, test procedures, standards, etc. and to adapt and often improve upon them for the Canadian context.

CCRL has provided the only technical input on residential oil heating since 1982, when the oil companies withdrew from all standards committees. CCRL has similarly provided critical technical input on wood heating, thereby filling a technical gap that neither the wood industry nor CSA could afford to provide. Thus, without CCRL's input, CSA oil and wood committees would not be able to function.

In addition to its technical capability, CCRL's influence on standards committees is greatly enhanced due to the perception among all parties concerned of its neutrality. This is particularly important when different fuels are being compared and questions of efficiency, safety and performance of individual manufacturers' products are being discussed.

3.3.5 RESEARCH LABORATORIES

Introduction

The selected interview sample included two independent research laboratories, the Ontario Research Foundation located in Mississauga, Ontario, and the Battelle-Columbus Laboratories, located in Columbus, Ohio. Both research laboratories operate on a not-for-profit basis and provide contract research and development assistance to industry, government and utilities. Battelle-Columbus has been working on fossil fuel heating systems for the residential, commercial and industrial sectors for over 20 years. The Ontario Research Foundation, through its Energy Systems Centre, operates nationally recognized, independent testing facilities for evaluating the performance of various products including residential heating, cooling, ventilating and chimney systems. The Energy Systems Centre also provides a wide range of energy technology assessment and engineering services.

CCRL Inputs and Reported Influence

A) Battelle-Columbus Laboratories

CCRL has worked closely with Battelle-Columbus Laboratories for more than 20 years, including work prior to the inception of the FFH Program. The three areas of particular involvement include:

- Combustion studies related to wood and oil heating system efficiency and emissions
- Fuel oil characterization
- Condensing heat exchangers

Battelle-Columbus and CCRL are also jointly involved on the U.S. Department of Energy's (DOE) Air Pollution Control Committee. Skip Hayden of CCRL is now chairman of this committee.

Throughout the duration of its involvement with Battelle-Columbus Laboratories, CCRL has continued to provide technical input and leadership related to all aspects of home heating appliance development and fuel characterization. However, CCRL's input to work on oil and wood heating systems has been particularly influential, especially during the 1979-82 period, when U.S. expertise and funding for oil heating systems declined dramatically. Battelle-Columbus reported that because of CCRL's world leadership and knowledge in combustion technology, its work has served as the basis for much of the U.S.'s recent work in this area; without CCRL's input, the U.S. and Battelle-Columbus expertise would be even further behind that of Canada. Similarly, Battelle-Columbus reported that CCRL's fuel characterization work has enabled Canadian and U.S. manufacturers and researchers to design oil furnaces which can handle various types of oil effectively and safely. CCRL's heat exchanger work was reported as having contributed significantly to an improved understanding of condensation in furnaces, which in turn has led to improved product designs.

The following excerpt from a 1980 DOE publication, "Technology for the Development of High Efficiency Oil-Fired Residential Heating Equipment", prepared by Battelle-Columbus Laboratories, was cited by the respondent as being indicative of CCRL's role and influence in the U.S.

> "...Table V-4 lists some of the recent publications of (the CCRL) Laboratory pertinent to residential oil heating. The technical quality of the R&D from this laboratory is excellent. Moreover, the field guidelines documents and consumer bulletins, prepared with the R&D as a basis, are especially effective. Attention is called to the reports and papers listed in Table V-4, with the suggestion that manufacturers and investigators in the U.S. can benefit from these publications and from following the work of this laboratory."

B) Ontario Research Foundation (ORF) - Energy Systems Centre

ORF reported that CCRL's input has been particularly related to two projects:

- The evaluation of prefabricated type-B wood stove chimneys (1982), and
- The testing of direct-vent gas furnaces to determine problems and solutions (1985/86).

In both cases, CCRL provided funding to ORF for the actual testing as well as providing technical input during the set up of test procedures and evaluation of results. Similarly, both projects reflect one of CCRL's ongoing roles, namely, anticipation of potential problems and initiation of steps to investigate them and develop possible solutions. In the case of chimney evaluations, ORF reported it was unlikely that the evaluations would have been carried out without CCRL's involvement. Due to the technology transfer from CCRL to ORF that occurred during the project, ORF is now able to provide ongoing chimney testing and product improvement services to manufacturers. In the case of the testing of direct vent gas furnaces, the need was jointly identified by CCRL and ORF, in conjunction with EMR's R-2000 and BETT programs. Again, CCRL provided technical input and coordination to the project. The project has proven to be very valuable in identifying potential problems and in identifying poor equipment designs, thus enhancing not only Canadian manufacturers' expertise, but also helping to better educate consumers about potentially problematic appliances.

3.3.6 CONSUMER ORGANIZATIONS

Introduction

There is a variety of organizations, associations and individuals in Canada that provide their audiences with advice related to the selection, installation and safe operation of consumer products. For the purposes of this project, interviews were held with representatives of two well-known, national consumer-oriented organizations:

- The Consumer's Association of Canada (CAC)
- CBC's Marketplace

Although their formal mandates differ somewhat in wording, both organizations share a common mission of providing well researched information and advice to Canadian consumers so as to enable them to make informed choices related to the purchase of products and services, as well as safe product installation and use. In both cases, the audience/membership is a very motivated one; surveys by the respective organizations have shown that their audience/membership is usually predisposed to researching their product purchases and taking action to ensure that only those products and services are purchased which provide good value. An average audience for each CBC Marketplace show is 1.3 million viewers, while CAC's subscriber list is about 150,000 households. A recent (February 1987) Marketplace show on wood heating safety drew a record audience of 1.6 million viewers and resulted in over 8,000 written viewer requests for additional information.

Marketplace produces about 22 shows per year; since 1974, about 15 shows or slightly more than 1 per year, on average, have been devoted to the subject of home heating. The topics covered have included:

- Woodstoves
  - product performance test results
  - safe installation and operation
  - product comparisons
  - fire hazards, installation, inspection, etc.

- Oil Furnaces
  - energy savings available through retrofits (flame retention head, etc.)
  - proper furnace servicing and maintenance procedures
  - specific new products and technologies available
  - product efficiencies

- Gas Furnaces
  - specific new products and technologies available
  - energy efficiency claims

- Zero Clearance Fireplaces
  - energy efficiency and safety
  - product availability

In about the same period, the CAC has run about 10 feature articles related to home heating appliances and literally dozens of smaller news stories on the topic. CAC has also conducted 3 or 4 product tests; a particular area of focus, in response to subscriber requests, has been wood heating. In each product test case, home heating products have been assessed on the basis of efficiency, safety, durability, handling and maintenance, and overall product recommendations were presented.

CCRL Inputs and Reported Influence

CCRL has provided similar inputs to both organizations: These include:

- Easy access and referral to background information, other experts, etc., as well as assistance in identifying key issues within a particular topic.
- Provision of an impartial review of the scientific issues involved in combustion and presentation of these concepts in easily understood terms which in turn enable CBC or CAC researchers to understand them for dissemination to their audience.
- Serving as an expert interviewee.
- Occasional access or use of CCRL's labs to provide photographs or film footage to show "how it works".
- Assistance to CAC in developing home heating performance testing procedures.

Because CCRL is widely recognized for its technical knowledge and neutrality, both CAC and CBC reported that reference to, or inclusion of CCRL within their articles or shows enhances audience acceptance of the facts being conveyed.

Further, it is very important to consumers that the source of expertise provided is Canadian, NOT U.S., and is therefore directly applicable to the Canadian context. Audience feedback has consistently shown an aversion to, and less credibility attached to, U.S.-oriented consumer advice. For example, CAC cited this fact as a primary reason for their publication's ability to continue to exist in Canada, despite the availability of the much larger U.S. publication, Consumer Report.

Finally, both organizations indicated that without CCRL, they would have to rely on other, predominantly U.S., sources of information. Given the added research costs and time involved, plus reduced audience acceptance of U.S. expertise, both reported that they probably would not have prepared as many shows or articles on home heating.

SECTION 4
PROGRAM EVALUATION RESULTS

4.1 INTRODUCTION

This section presents the key findings obtained from the extensive interviews carried out during the project. The results are organized and presented in relation to global program issues as previously identified in Section 1.

The following global program issues are addressed:

- **New and Improved Home Heating Technologies Developed**
  - What are they?
  - What is their current and projected future market penetration?
  - What has been the impact of the FFH Program on these developments?
- **Program Activities and Roles**
  - What are the key roles and contributions provided by the Program to the various constituencies? Do they complement, duplicate, or hinder those of other firms and organizations?
  - What is the relative importance of each of the FFH Program's activity areas? Are any redundant or in need of major change?
  - What has been the relation of the FFH Program to other related EMR programs?
- **Program Cost-Benefit**
  - Benefits to consumers
  - Benefits to equipment manufacturers
  - Benefits to non-manufacturing organizations and government departments
- **Future Role of the Program**
  - Is there a need to continue the Program?
  - If so, are there structural or other Program changes that would enhance its relevance and effectiveness?

Evaluation results are provided below for each of the above issues.

4.2 NEW AND IMPROVED HOME HEATING TECHNOLOGIES

4.2.1 The Technologies

As further illustrated in Figure 4.1, in the period 1971 to present, there have been very substantial efficiency, safety and emissions improvements to home heating appliances of all fuels. Specifically:

- New non-condensing oil furnace products are now available. These operate at a seasonal efficiency of 85-87%. This represents a very substantial improvement over the oil furnaces available in 1971 which typically operated at a seasonal efficiency of about 60%. Although new condensing oil furnaces provide modest additional gains in efficiency, they are subject to corrosion problems. Production of condensing oil furnaces is expected to be phased out.

- New condensing and induced draft (mid-efficiency) gas furnaces provide seasonal efficiencies in the range of 95% and 85%, respectively.

- New hybrid (space and water heating) gas and oil systems are now entering the market and are especially suited to the reduced thermal needs of low energy housing. Although they do not provide any substantial performance improvements over other stand-alone efficient units, they do provide additional consumer cost savings due to component sharing.

- Advanced wood stove designs not only provide steady state efficiencies approaching 80%--in comparison to 50% for conventional box stoves--but they also are much cleaner burning. Additional design features have also improved their safety and convenience.

4.2.2 Market Penetration

As also illustrated in Figure 4.1, these new, more energy-efficient heating products are achieving significant Canadian market penetration. Specifically, manufacturers report that:

- Virtually all new oil furnace systems are equipped with high efficiency burners, providing seasonal efficiency ratings in the 70-75% range and new high efficiency oil systems, providing seasonal efficiencies in the range of 85-87%, are expected to show good market penetration in the near future.

- Mid-efficiency and condensing gas furnaces currently represent about 30-40% of new gas furnace sales; this is expected to increase to over 50% by 1990, with sales of the mid-efficiency units being particularly strong.

- Although comparable market data are not available for wood stoves, it was clear from discussions with manufacturers that minimum efficiency and emissions standards development work in the U.S. and Canada clearly indicate to them that the future for conventional inefficient stoves is limited.

FIGURE 4.1
NEW/IMPROVED PRODUCT DEVELOPMENTS

Fuel Type	Product/ Technology	Application	Approx Market Entry Date	Current Market Position	Performance	Estimated Future Sales (1990)
Fuel Oil	. Flame retention head burner	. New, and . Retrofit	. Early 1970's	. Installed on nearly all new furnaces	. 10-20% savings fuel	. Steady sales
	. Chimney Damper	. New and Retrofit	. late 1970's	. Low sales	. 3-11% fuel saving	. Increased sales
	. Flame retention head retrofit kit	. Retrofit	. early 1980's	. very few sales	. 10-20% fuel savings	. No growth in sales
	. High pressure, forced draft burner; no barometric damper; carefully sized firing rate; high static pressure fan	. New	. mid 1980's	. just entering market	. 85-87% seasonal efficiency . 25-27% fuel saving	. Increased sales
	. Condensing Oil	. New	. early 1980's	. low sales	. 85-95%, seasonal efficiency . 25-35% fuel saving	. Unlikely to remain in market, due to corrosion problem
	. Advanced efficiency space and water heater	. New Low Energy housing	. present	. Just entering market	. N/A	. Increased sales

FIGURE 4.1
NEW/IMPROVED PRODUCT DEVELOPMENTS
CONT'D

Fuel Type	Product/ Technology	Application	Approx Market Entry Data	Current Market Position	Performance	Estimated Future Sales (1990)
Natural Gas	. Retrofit Condensing furnace	. Retrofit	. 1985	. Low sales	. 25-30% fuel savings	. Continued low sales
	. Condensing	. New	. early 1980's	. 30-40% of gas sales	. 90-95% seasonal efficiency . 30-35% fuel saving	. Sales of medium efficiency and condensing furnaces are expected to exceed 50% by 1990
	. Mid Efficiency	. New	. early to mid 1980's		. 80-85% seasonal efficiency . 20-25% fuel savings	
	. Plastic Heat Exchanger	. New	. not yet commercially available	---	. reduced product cost	---
Wood	. Simple box stove	N/A	--	No data	Base (50% steady state efficiency)	. Declining sales due to influence of efficiency and emission standards; these stoves do not meet performance criteria
	. Secondary Combination Designs - Interior Baffle - Side Draft - Down Draft	. N/A	. mid 1970's	. major drop in sales volume from 1981/82 . Generally stable sales in most regions	. 65-75%, (steady state efficiency) . Reduced emissions	. N/A

FIGURE 4.1
NEW/IMPROVED PRODUCT DEVELOPMENTS
CONT'D

Fuel Type	Product/ Technology	Application	Approx Market Entry Date	Current Market Position	Performance	Estimated Future Sales (1990)
Wood (cont'd)	. Catalytic	. N/A	. 1980	. Modest sales	. 70-80% steady-state efficiency . further emissions reduction	. Steady, perhaps modest growth . May face increased competition from high efficiency non-catalytic models
	. High Efficiency, Low emission, Non-catalyst	. N/A	. Small unit, - 1983 . Larger units - 1987/88	. Low volume	. Meets U.S. EPA emission standards . 70-=80% steady state efficiency	. Expected sales increase, especially in export market

In addition, export sales of Canadian manufactured furnaces and wood stoves have also increased substantially over the period 1971-1986. In 1971, reported export sales by the manufacturers sampled was less than 2% of production; however, by 1986, that number had risen to 30%. Manufacturers noted that U.S. consumers generally consider Canadian furnace manufacturers to have more product expertise than U.S. firms.

Products have also been developed and certified for retrofit applications. These products, principally the flame retention head retrofit kit for oil furnaces, and the retrofit condensing gas furnace, provide potential fuel efficiency improvements of 10-20% and 25-30%, respectively, over conventional units. Sales of these products have, however, been limited to a few hundred units per year.

4.2.3 CCRL Impact on New and Improved Product Development

As discussed previously in Section 3.3, the specific impact of the FFH Program's involvement in new and improved product development has varied both by product and in accordance with the nature of the Program's involvement.

The Program has provided financial as well as technical input to those listed below with the following resulting impact:

- Manufacturers reported that the flame retention head oil burner retrofit kit and the retrofit condensing gas furnace would not have been developed and commercialized without CCRL's ongoing technical and financial support.
- Similarly, development of the advanced efficiency, combined oil-fired space and water heaters would have, at a minimum, been delayed by several years.
- Developments and improvements to advanced efficiency gas furnaces have benefited significantly from the technical and financial support provided by the Program for field testing and performance evaluations.

In addition to those product development areas where the FFH Program has provided direct financial and technical support, it has also exerted significant, but less direct influence on product development through its related technology transfer, liaison and standards development activities.

- 28% of the manufacturers sampled reported that the Program had exerted a very strong and direct influence on their firm's product development decisions. In these cases, virtually all new major product developments were discussed in advance of market introduction with Program personnel; any potential product performance problems and concerns noted by CCRL from its own experience were thoroughly investigated and resolved before the firm proceeded. On the other hand, CCRL's endorsement of the design served as a critical second opinion which, if in agreement with the firm's own positive assessment, would virtually ensure continued product development and subsequent market introduction.

- 21% of the manufacturers sampled reported modest Program influence on their product development decisions. In these cases, the firms reported that they periodically sought CCRL's opinions related to particular design changes or improvements.

- 51% reported no direct CCRL influence in any of their firms' product development decisions. These firms were principally, but not exclusively, wood stove manufacturers.

4.3 FFH PROGRAM ACTIVITIES AND ROLES

The response of interviewees to questions related to the nature and adequacy of CCRL's program activities and roles showed a very high degree of uniformity. This was particularly the case among non-manufacturing organizations where more than 90% of the sample reported that the program provided "invaluable" or very important inputs to their own activities in the home heating areas. More specifically:

4.3.1 Major Roles

- The program provides guidance and leadership to all aspects of the home heating industry:
    - It provides an important network function between all of the various interests e.g., manufacturers, suppliers, governments, consumer organizations, etc. It provides a credible, visible and accessible source of technical and market information.
    - It continues to keep 2 to 3 years ahead in technology development and therefore helps manufacturers, standards agencies, government policy and program personnel to both anticipate problems and to develop solutions when a new technical problem or market demand arises.
    - A particularly important program attribute, enabling it to perform the above leadership role, is the fact that it combines respected technical capability with "neutrality". This combination of technical capability and neutrality provides the program with a unique level of industry and consumer acceptance and credibility. Other centres having technical capability in a given area do exist in Canada, e.g., CMHC and CGRI, but each has either conflicting mandates or inherent conflict of interest. Thus the FFH Program is able to play the important role of impartial arbiter in areas of technical controversy. As a recent example, when concerns were raised over air quality in tightly sealed houses containing certain gas appliances, several manufacturers and research agencies disputed the possibility of potential problems; however, when CCRL confirmed the validity of the concerns, remedial actions were initiated.
    - The FFH Program provides a Canadian perspective because it deals with Canadian products, markets and climate conditions. Although foreign (U.S. and Europe) sources of technical expertise exist and are periodically accessed by the Canadian home heating industry, their products and market conditions differ from those in Canada, requiring user adaptation and interpretation for Canadian application. Thus their results, though useful, do not have the same level of credibility among consumers or industry interests as do those from the FFH Program.
    - Finally, the FFH Program enjoys an international reputation for its technical capability in home heating systems and has not only provided valuable input to many foreign sources of expertise but

also CCRL involvement in related works of other Canadian agencies (e.g., CMHC and its house-as-a-system work) lends additional international credibility to their work.

4.3.2 Relative Importance of Activity Streams

- Each of the Program's 4 major activity streams--R&D, technology transfer, liaison and standards development--represents an integral element of the overall service provided; although the program's R&D work, both in the lab and in the field, provides the program's essential technology base, the remaining activity streams are not only essential to ensuring effective transfer of that R&D knowledge but also to providing the critical interactive linkages which ensure that the R&D activities themselves are in line with the overall needs of industry.

4.3.3 Relative Importance of Outputs by Constituency

- In general, the non-manufacturing constituencies--standards development, consumer organizations, government departments--rated the benefits derived by them from the FFH Program even more highly than did manufacturers. In more than 90% of cases, respondents rated the FFH Program services as being either invaluable or very important to them. In most cases, if the FFH Program did not exist they indicated that such a resource would have to be created in order for them to continue to fulfill their mandate.

- The majority view of the equipment manufacturers was also one of strong support for the Program. However, the degree of perceived benefit by manufacturers was influenced both by their size and by fuel source. In general, smaller independent firms, involved particularly in the manufacture of oil heating products, expressed strongest need for the Program as they did not have the necessary resources to fully assess and keep pace with new technology developments on their own.

- Larger firms, and particularly those involved in the manufacturing of gas appliances, indicated greater ability to carry out in-house product development and to access other technical resources. However, here too the FFH Program is acknowledged to have provided technical, testing and field experience input in support of their production decisions.

4.3.4 Relation to Other EMR Programs

The FFH Program has provided valuable technical input to both the design and delivery of a variety of EMR residential programs, including the Canadian Home Insulation Program (CHIP) and the Canadian Oil Substitution Program (COSP). EMR's regional Conservation and Renewable Energy Offices (CREOs) have been involved extensively in the transfer of residential furnace technology; the FFH Program has served as a major source of their technical information on residential oil, gas and wood heating systems.

4.4 PROGRAM COST-BENEFIT

4.4.1 Approach

The performance of a true cost-benefit analysis was not included in the terms of reference of this study. The intention was to gather quantitative information as available from the interview respondents and to put these data into a cost-benefit context as appropriate.

This approach was adopted because cost-benefit was not the prime objective of the study, and because it would require much greater resources to perform a cost-benefit analysis. The most important additional information that would be required to perform a true cost-benefit analysis is a measure of the incremental value of the program to its clientele and society generally. A reliable estimate of such a measure would be difficult to obtain.

In the absence of the information required for a true cost-benefit analysis, we have made partially subjective assessments of the incremental impacts of the program and of the value of program benefits based on information from the detailed interviews and from program officers. These estimates serve to indicate a range, or order of magnitude, of the program benefits.

Some program benefits have not been quantified, as outlined below. Those benefits which are quantified have been done so on a "conservative" basis, meaning that the estimates are really a lower limit of the true benefits. Since these benefits are shown to be significantly greater than the program costs, it is clear that the program, in its recent and current form, has net overall benefits to society.

Because the FFH Program has been operating since 1971, some if its currently visible successes have resulted from activities undertaken over the long time period from 1971 to the present. Not only does it take a long time for R&D oriented work to bear fruit in the marketplace, but a significant part of the value of this program (as mentioned repeatedly by the interview respondents) results from its neutrality and credibility with manufacturers, consumers, regulatory agencies and standards groups. Such value can only be built up over time.

This attribute of the program makes it even more difficult to estimate resultant benefits. Detailed information on incremental impacts over many years, and projected impacts for the future, would be necessary to calculate program benefits.

In place of examining the dynamic benefits of the program, both past and future, we have approximated these multi-year costs and benefits by applying the following procedure:

- estimate program costs over its 15-year lifetime, and calculate 1987 present value of these costs,
- estimate incremental net benefits which accrue to manufacturers, and net benefits due to energy savings which accrue to residential homeowners, for a recent year and multiply these benefits by three (see

below) to approximate the total benefits which have accrued over the 15-year program period, and

- assess the net benefits to the FFH Program constituencies other than manufacturers and homeowners on the basis of alternative costs.

The factor of three applied in the second step listed above is somewhat arbitrary. If incremental program benefits were constant each year, the appropriate factor to present value future benefits to the base year would be over ten (assuming a 20-year time period and seven percent per year real discount rate) rather than three. But past benefits have increased over time to their current levels. Future benefits cannot all be claimed to be incremental benefits, since R&D activity would have led to product improvements over time. The factor of three, although arbitrary, is argued to be conservative in the sense that it is anticipated that the true value is between three and ten.

The estimate of benefits due to the program must be restricted to incremental benefits, i.e., those which would not otherwise accrue if there were no program. In our estimate of incremental benefits described below, only data from those organizations interviewed for this study have been used. The survey of manufacturers of furnaces and stoves was not a census; the sample selected for interview did, however, include every firm that had significant direct contact with the program over the study period. This sample accounted for more than half of the market for these products. By the definition of incrementality, however, any firm with (direct) incremental impacts due to the program has been included in our study survey.

There are incremental benefits which have been omitted from our analysis. These are indirect benefits to a firm through a third party, say, an association. In addition, we have not been able to quantify reliably the benefits resulting from the training of furnace maintenance and service personnel, training that can, in part, be attributed to the program.

4.4.2 Estimated Program Costs

Program costs have been calculated based on person-year estimates of program resources over the 15 year period 1971-1986 (FY 71-72 to FY 85-86). Without having actual salary, capital and O&M costs for the program, we have estimated the total program costs (from a societal perspective) using $100K (in 1987 constant dollars) per person year. This estimate is likely to be high, but it provides a conservative estimate from a program net benefit point-of-view.* In addition to these person-year and facility resources, the program has a budget for external contract work. Estimates for contract work have been added to the basic program resources.

These estimates are shown in the following Figure 4.2. Note that the adjustment of Program resources used in earlier years, to be equivalent in present-value terms** to resources used in later years, actually increases the value of earlier-year resources. The $200K (1987 constant dollars) resources used in FY71-72 are equivalent to $552K in 1987 present-value terms.

FIGURE 4.2
ESTIMATED PROGRAM COSTS

YEAR	PERSON-YEARS	EXTERNAL CONTRACT DOLLARS ($000)	VALUE IN 1987 CONSTANT DOLLARS IN YEAR OF USE ($000)	PRESENT VALUE IN 1987 ($000)
71-72	2	0	200	552
72-73	2	0	200	516
73-74	2	0	200	482
74-75	2	0	200	450
75-76	2	0	200	421
76-77	3	100	400	787
77-78	3	100	400	735
78-79	4	100	500	859
79-80	4	100	500	803
80-81	7	175	875	1313
81-82	7	175	875	1227
82-83	7	175	875	1147
83-84	7	175	875	1072
84-85	7	175	875	1002
85-86	7	175	875	936
			TOTAL	$12302

---

* It should be noted that in the 1971-78 period approximately 40% of the FFH Program's costs were provided by private sector sources.

** For all calculations involving present value in this study, an interest rate of seven percent per year, exclusive of inflation, has been used. This value is consistent with the guide for cost-benefit analysis prepared by the Program Evaluation Branch of EMR.

4.4.3 Estimated Benefits to Manufacturers

As a result of the CCRL FFH program, some manufacturers in Canada benefit from increased sales, including increased exports. Benefits resulting from product improvements in terms of energy efficiency are benefits which accrue to the homeowner, the purchaser of the product. These benefits are estimated in the following section. Market share advantages among Canadian manufacturers are not net benefits from a societal point of view if one manufacturer's gain is another's loss. However, benefits do occur when:

- Motivated by the fuel cost savings provided by new, more efficient heating appliances, consumers replace their existing furnace before the end of its lifetime or they purchase a supplementary heating appliance, such as a wood stove.
- Canadian manufactured heating appliances are purchased instead of imported units.
- Canadian manufactured heating appliances gain increased export sales.

The manufacturers' interviews indicated that increased sales have occurred as a result of each of the above. However, within the scope of this study, data were available only with respect to increased exports. Thus, the only benefit estimated herein is the benefit accruing to the manufacturer, and to the Canadian economy, of increased exports of related products. The estimated benefit to manufacturers is, therefore, conservative.

The economic value of increased exports is best measured by the profit margin, before tax, on the export sales. If the export sales are considered to be the marginal product of a basic Canadian operation, a profit margin of 20% of sales before tax is a conservative estimate.

The estimated export benefits must account for the assessed incremental influence of the program. This program incrementality has been assessed for each interview respondent. The values for incrementality have been assessed in terms of a nominal value and as a range with a low and high value. It is assumed that the program influence is the same for both domestic and export purposes, as shown in the table below.

The reported export sales percentage has been applied to that portion of sale that is related to the FFH program.

As shown in Figure 4.3 below, the estimated incremental net export benefits are $1.16 million for the nominal value of assessed incrementality. For low and high estimates of incrementality for each respondent, this value ranges from $0.74 million to $1.74 million, as shown in Appendix C.

4.4.4 Estimated Benefits to Homeowners

Benefits to homeowners accrue from increased safety and air quality as well as the increased energy efficiency of the purchased equipment. We have quantified only the energy savings benefits. Energy savings due to

FIGURE 4.3
ESTIMATION OF NET BENEFITS FOR MANUFACTURERS AND HOMEOWNERS

Man.	Principal Product	Recent Year Units (000)	Export %	Program Relevant Sales $(000)	EE % of Product percent	Ass't Incr. %	Export Benefit $(000)	Present Value Savings $(000)
A.	oil burners & kits	25	70	5,000	99	40	840	8,197
B.	gas furnaces	15	40	1,700	35	50	204	1,748
C.	gas furnaces	58	40	0	30	0	0	0
D.	furnaces	9	10	0	0	0	0	0
E.	woodstoves	4	0	1,400	100	50	0	5,520
F.	gas furnaces	11	0	120	100	5	0	611
G.	woodstoves	10	0	2,000	0	0	0	0
H.	furnaces & boilers	3	5	1,200	70	10	4	551
I.	woodstoves & inserts	8	80	4,500	20	5	106	44
J.	oil B&F wood F&S	10	3	400	50	5	0	669
K.	woodstoves & inserts	1.5	10	800	50	0	0	0
L.	woodstoves & furnace	1.7	3	2,000	100	10	4	455
M.	oil furn +	5	1	6,500	5	0	0	0
					TOTAL:		$1,160	$17,795

Note: See Appendix C for definition of entries and other notes to this table.

increased efficiency of better service of previously installed equipment have also not been included.

Net benefits to homeowners have been estimated as the present value of estimated energy savings over the lifetime of the equipment less increased cost to the homeowners of the energy efficient equipment.

The increased efficiency of the equipment was assumed to save the homeowner 20 gigajoules (GJ) of secondary energy per year on average. This value of energy savings is consistent with an average 20% efficiency improvement for houses using 100 to 110 GJ per year for space heating. A low of 15 GJ and a high of 25 GJ has been included in calculations detailed in Appendix C.

The value of these energy savings has been calculated using EMR projected social opportunity costs (SOCs) of energy products for the residential sector. These projected SOCs to 2005 have been present valued to 1987 values using a seven percent per year (real) discount rate.

The increased cost to the homeowner of the energy efficient equipment has been arbitrarily set at one half of the SOC of the 20-year present value of energy savings. This estimate of cost is conservative in the sense that in other studies it has been shown that the homeowner is usually unwilling to pay the 20-year SOC value of energy savings, and the degree of difference between willingness-to-pay and SOC is usually more than a factor of two.

Table 4.2 below shows the estimated values of incremental net benefits to homeowners for nominal values of incrementality and energy savings. These values are calculated for the same range of incrementality estimates indicated above, and for the range of energy savings estimates from 15 to 25 GJ per year in Appendix C. As shown in the table, the total present value of incremental net benefits is $18.8 million. These benefits could range from a low of $7.1 million to a high of $33.7 million. This range indicates the uncertainty of the information on which our estimates are based. The low and high estimates indicate uncertainty around a conservative estimate of benefits, not the range of total benefits.

Excluded from this estimate are the benefits due to better servicing of furnaces. The estimates are conservative from the point of view of the factor of three used to represent multi-year benefits. The range of energy savings (15 to 25 GJ per year) is also on the conservative side.

4.4.5 Estimated Benefits to Non-Manufacturing CCRL Constituencies

The benefits due to the Program which accrue to the non-manufacturing constituencies result from the technical input and advice provided by the program to associations, governments and other organizations as outlined above. These benefits are often related to safety and air quality standards and therefore are additional to the energy savings benefits estimated above. These additional benefits are very difficult to quantify without performing in-depth questioning on alternatives available to these organizations and their willingness to pay for these services.

We have summarized the comments made by these organizations with respect to the influence and importance of the FFH Program to them (see Section 3.3).

Based on these comments, if the FFH Program did not exist, it would have to be created to meet the needs of these constituencies. The cost of such an alternative would be approximately what the existing program has cost.

It is therefore argued that the basic Program costs are equal to or less than the benefits to these constituencies.

4.4.6 Summary of Costs and Benefits

Program costs to date are estimated to be $12.3M in 1987 present value terms.

Using the nominal estimates of benefits for value of exports and value of energy savings to homeowners, we have total incremental benefits of $1.16M + $18.8M, or $20M. Benefits to constituencies other than manufacturers, and other than energy savings, are argued to be at least as large as Program costs (i.e., $12.3M). Other benefits have not been quantified.

Total quantified benefits are therefore at least $32.3M for Program costs of $12.3M.

4.5 FUTURE ROLE OF THE PROGRAM

4.5.1 Program Rationale

Based on interviewee response, it is clear that there is very strong industry support not only for continuation of the present FFH Program, but also for its expansion.

- Among the non-manufacturing constituencies, 88% of respondents not only supported a continued rationale for the program but also indicated that additional program resources, in the form of both additional personnel and program funds, were desirable in order that their organizations' work, as well as the industry's needs as a whole could further benefit from the Program. The remaining 12% expressed strong support for the Program's continuation, but were generally satisfied with the present level of support provided. None suggested any reduction for the role played by the Program or the resources currently allocated to it.

- Among the manufacturing firms, there was similarly strong support for continuation of the Program's role; none suggested any reduction. Although only 1 manufacturer explicitly recommended increased program resources, 71% did recommend additional activities that they would like to see the Program undertake, thereby implicitly suggesting that Program resources be increased.

- Finally, both the manufacturing and non-manufacturing constituencies emphasized that the Program's role would become even more critical if a Free Trade Agreement is established with the U.S. If such an agreement occurs, it is anticipated that many new U.S. manufactured residential heating products will enter the Canadian market, thus greatly increasing the need for a knowledgeable and neutral body, such as CCRL, to assist consumers, equipment manufacturers, government departments and standard agencies to assess these products. Similarly, CCRL's knowledge of related U.S. standards and market conditions would be invaluable to Canadian manufacturers seeking to compete in U.S. markets.

4.5.2 Recommended Changes

The recommended Program changes, as cited by the interview respondents, are best grouped into two categories:

- those that do not affect the scope of current Program activities, but rather are intended to increase the efficiency and effectiveness of information transfer from the Program to its clients, and

- those that represent new activity areas and hence, expand the current Program's scope.

Each is addressed separately below.

A) Changes Within Current Scope

Respondents from both the manufacturing and non-manufacturing constituencies were very consistent in their critique of the current Program and were equally consistent in many of their suggested changes. All critiques and suggested changes related to increased access to the Program's highly respected knowledge base as well as increased access to senior Program staff.

Although (as reported above) the vast majority of respondents reported very significant benefits from their personal interaction with the Program, approximately 75% of all respondents indicated that they were not aware of the full range of activities, technical information, and current R&D initiatives within the Program. Additional knowledge of this information combined with reasonable access to it, was repeatedly cited as being an important prerequisite to increased Program effectiveness. **Thus, the most frequently cited request was for the FFH Program to initiate a regular newsletter to all constituencies which would:**

- **be issued on, say, a quarterly, semi-annual or even annual basis**
- **provide an overview of current Program R&D activities, interim results, etc. and refer to emerging products or trends, etc.**
- **provide a list of relevant technical papers or documents which could be accessed by the reader either from CCRL or from other sources.**

The example of the newsletter published by the Gas Research Institute (GRI) in the U.S. was cited as a typical model.

Approximately 20% of the respondents noted that the demands on senior Program staff time were excessive and thereby restricted, in some cases, the level and timeliness of their inputs. At the same time, however, all respondents acknowledged the legitimacy of the various competing demands on staff time; thus this group, in particular, felt that increased administrative and technical personnel resources should be allocated to the Program, enabling senior Program staff more time to interact in a timely way with their clients. The importance of this latter point was further reinforced by several respondents concerned about the Program's continuity, who noted that the Program's effectiveness is presently very dependent on one or two individuals.

A related access issue--the frustration of dealing with the Bells Corners Complex's switchboard when trying to reach Program personnel--was cited on several occasions as further evidence of the need to provide better administrative support to the Program.

B) Expansion of Current Scope

Approximately 10% of respondents suggested new program activity areas. These are listed below:

- Two respondents indicated that they would like to see CCRL become more involved in specific home heating product testing and evaluation. In both cases, the example of ORF's testing and production of factual performance data as well as qualitative assessments of HRV units was cited as an example of the type of service being sought.

- Three respondents cited their desire to see the Program expanded to provide a similar range of services to commercial and industrial space heating products.

4.6 SUMMARY AND RECOMMENDATIONS

Based on both the interview results and the Program cost-benefit results reported here, it is clear that the Fossil Fuel Heating Program has provided substantial net benefits to Canadian society. Similarly, the Program is widely respected by all parties involved with it and has developed an international reputation for its excellence in fossil fuel combustion research and development. The technical expertise provided by the Program is undoubtedly one of the significant elements contributing to the international recognition of the high quality of Canadian residential furnaces. Furthermore, the role played by the Program is widely recognized as being an excellent model for government involvement in industrial R&D and product development. The combination of technical capability and neutral approach to the technologies involved is the key to the Program's overall influence, leadership and acceptance. The extensive list of related new developments being launched or planned for market entry add additional weight to the recommended continuation of the Program. Indeed, it is our opinion that a case for modest expansion of the Program's resources is justifiable.

Finally, it is also evident that the Program's efficiency and effectiveness can be augmented by increased senior management attention to the administrative and communications issues earlier cited.

APPENDIX A
SAMPLE INTERVIEW GUIDES

INTERVIEW GUIDE

-NON-MANUFACTURING-

PART A: BACKGROUND AND INTRODUCTION

A1 Name of Organization/Department:______________________________

A2 Location:______________________________

A3 Name of person being interviewed:______________________________

Title:______________________________

A4 Preamble and background of the project and why we are conducting this and other interviews

- Cite areas of known involvement with CANMET (from documentation)
- Overall from these interviews we would like to:

a) Identify and briefly document the mandate and scope of major activities of those organizations (in addition to firms) with whom CANMET's FFHP has had contact or provided support to related to home heating.

b) Identify the specific activity areas of your organization where FFHP personnel have provided input and establish your views on the value/impact of that input on your organization.

c) Obtain your views on what optimum roles (if any) this program could or should play in the future, either with respect to assisting your organization in particular, or the home heating industry and consumer market in general.

A5 Before moving to specifics, perhaps we could begin by getting some general background information on your organization. This will help us to further define and/or clarify the range of constituencies that the FFHP interacts with related to home heating. I realize that the period 1971-1986 spans quite a few years and that much has undoubetedly changed over that time. Perhaps you could begin with the present and compare this to, say, 5-10 years ago or alternately to the period in which your organization's home heating related activities were most intense.

In particular with respect to only the home heating area, would you comment on:

a) Mandate/Objectives

Now: ____________________
____
____
Then: (Date)____________________
____
____

- Major Activities/Programs/Projects etc.

Now: ____________________
____
____
Then: ____________________
____
____

- Major Target Groups/Members etc.

  Now: ____________________

  (If members, how many) ____________________

  Then: ____________________

  (If members, how many) ____________________

- Annual Budget and Staff

  Now: ____________________

  Then: ____________________

A6 With respect to the above noted activities, projects, programs etc., which one(s) do you feel have achieved the most significant results/impacts vis-a-vis meeting your mandate? What were the impacts achieved/impact on target group/impact on consumers/industry etc. (as appropriate)?

Achievement	Date	Impact(s)

PART B: CANMET IMPACT

B1 As mentioned previously, our discussions with Skip Hayden at CANMET indicated that areas of involvement with you/your organization included_______________(from documentation).

(confirm/amend)

I would like to know focus specifically on____________(area(s) noted in B1) (For each)

AREA 1:

Name/Description ____

____

a) When and how do you come into contact with the FFHP?__________

____

____

b) What specific inputs did/do they provide (e.g. knowledge of the technology or testing procedures/results, market or industry knowledge etc.)____

____

Relative importance of each?__________________________________

____

____

____

c) What impact/influence did their input have on your oganization's work in this area/project program? For example,

. helped your organization to define overall direction/objectives/procedures etc.

- helped your organization to overcome/resolve technical issues/impediments etc.

d) What was the overall impact of this project/initiatives etc. on your organization's target group(s)? (e.g. nature of influence and number affected)

- Would this result have been seriously affected without CANMET's input? Please explain.

Repeat above (if Applicable) - for AREA 2

Name/Description

a) Contact (When & how)

b) Inputs

c) Impact on Organization

d) Project Impact

- Results without CANMET

B2 More generally, how frequently would you say that your organization refers to or comes into contact with CANMET generated home heating knowledge?

- How influential is/has been this knowledge or contact in affecting your organization's activities and expenditures in the home heating area? Please specify.

B3 Are the results of CANMET's home heating activities applied directly in your organization? If so, please explain in what way.

B4 Has your organization been affected by or benefitted from CCRL's activities in the following areas:

- **joint participation** on the development of standards, regulations, policies or programs, procedures, information bulletins, etc.? Please give examples.

- **information dissemination:**

- increased awareness and knowledge within your organization of technical issues of home heating?

- increased awareness and knowledge of others with whom you interact?

- is information desseminated from CANMET timely? Of excellent quality? Of practical use?

- **modified environment:**

- have CANMET activities provided an environment that has assisted your organization to accomplish its objective? ______________

- have energy conservation attitudes, awareness and knowledge been affected by CANMET activities in a way that affects your organization? ______________

- have other government programs or actions been affected by CANMET which affect your organization's activities? ______________

- have equipment manufacturers, equipment suppliers, home builders, homeowners, etc. been affected by CANMET in a way which affects what your organization does? ______________

- have regulations, standards, practices, etc. been developed which effect your organization? ______________

- have new products, technologies, testing procedures etc. been developed by CANMET which affect your organization? ______________

B5 **How could CANMET change its home heating program to make it easier for your organization to better achieve its objectives in the** efficient and safe use of energy, in the residential sector?

B6 Do you have any additional comments?

Thank you

INTERVIEW GUIDE
-MANUFACTURERS-

PART A: BACKGROUND & INTRODUCTION

A1 Name of firm: ______________________________

A2 Location: ______________________________

A3 Name of person being interviewed: ______________________________

Title: ______________________________

A4 Preamble and background of project and why we are conducting this and other interviews

- cite areas of known involvement of firm with CANMET (from documentation)

- objective of interview is to:

a) Identify and document the nature and extent of your firm's interaction with CANMET's FFH program - either directly or indirectly (explain);

---

b) Establish your views on the value/impact of the program specifically on your firm's product development and sales as well as more generally on consumers and the home heating industry as a whole, and;

c) Obtain your views on what optimum roles (if any) this program could/or should play in the future.

A5 Before addressing the above points, however, it would be helpful to us if we could first get some general background on your firm. This information will help us to broadly characterize the present residential heating industry and market context. All information will be used only in an aggregate form.

a) when did your firm first begin to manufacture and market residential space heating equipment?________________

b) Current range of home heating products manufactured and sold:

	Yes	No	% of Sales
Oil furnaces	___	___	___
Oil burners	___	___	___
Gas furnaces	___	___	___
Wood furnaces	___	___	___
Wood stoves	___	___	___
Combination	___	___	___
Other _______	___	___	___
Other _______	___	___	___

With respect to only residential space heating equipment:

- Approximate 1986 annual sales $______________
- Approximate 1986 no. of employees ______________
- Approximate 1986 no. of units sold ______________

- Approximate 1971 (or a) annual sales $______________
- Approximate 1971 (or a) no. of employees ______________
- Approximate 1971 (or a) no. of employees ______________

d) Do you export any of your products? Yes________ No________

- If yes, approximately what percentage? 1986____% 1971____%
- Which models or types ______________________________________

____

____

e) Current (1986/87) and estimated (1990) sales of Enhanced Efficiency (EE) heating products as % of total for each fuel type (EE to be defined by interviewer).

	1986/87	1990	
EE oil furnace	______%	_____%	of total oil furnace sales
EE oil burners	______%	_____%	of total oil burner sales
EE gas furnace	______%	_____%	of total gas furnace sales

or General outlook for sales growth of EE home heating appliances.

f) What are the major new EE home heating products or product improvements that your firm has introduced over the course of the past 10-15 years? When were they introduced?

New Product/Improvement	Introduction Date
1. ______________________	
2. ______________________	
3. ______________________	

4. ______________________________
5. ______________________________
6. ______________________________
7. ______________________________

g) Finally, how does your firm develop new or improved products for market? Can you give me a brief overview? For example ,

- Does you firm have a separate R & D group? If so, how many employees? Has this number changed significantly over the past 15 years?

- If your firm does not have an R & D group how does it achieve new product development? e.g. import foreign/parent company products, etc.

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PART B: CANMET IMPACTS

B1 As mentioned previously, our discussions with Skip Hayden indicated your contact with CANMET's FFHP included------------------(from documentation). If no contact, go to B7.

(confirm and/or amend)

Can you provide me with some details (re: above)? For example,

- When did you first come into contact with the program?______________

- How ? ____

- What assistance was provided or has been provided over the years? (e.g. product testing, design, marketing etc.)

- Has this contact with CANMET influenced your firm's R & D or product development and marketing activities? Can you give some examples? For example, has this contact affected the design, marketing, timing of introduction etc. for any of the new products or improvements that you cited above (A5f)? Can you be specific regarding how this contact affected them?

B2 How and why did you get involved with CANMET in this/these particular project/s?

- they came to us with the concept ________________________________
- insufficient funds in our R & D budget to do this project at all __

- risk seen as to great ____________________
  - technical ________
  - financial ________
  - other (specify) ____
- other (specify) ____________________

____

____

B3 What would your firm have done with respect to this/these particular project/s without CANMET's involvement?

- would have gone ahead anyway ____________
- probably would have gone ahead ____________
- probably would have gone ahead but at a later date ________
- probably would have scaled it down ____________
- probably would not have gone ahead ____________
- would not have gone ahead at all ____________
- don't know ____________

Please explain

____

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B4 More generally, how frequent is the contact between your firm and CANMET researchers?

____

____

How is this generally accomplished (e.g. phone, site-visit, seminar contact etc.)? ____________________

____

B5 Has your firm ever approached CANMET directly with a specific request for technical or other assistance related to home heating?

- If Yes, please specify.

- How timely and beneficial was their response?

B6 Has your firm ever been approached by CANMET for your views on defining their research objectives or activities?

- If Yes, please specify.

- What were the results?

B7 Are there other organizations with whom your firm maintains regular or periodic contact. Which ones? Primary purpose?

____

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B8 CANMET's activities in the home heating area also include: involvement in the development of standards, and regulations; the on-going preparation and presentation of technical papers related to home heating system advancements; training sessions; public presentations; consumer publications etc. Have these or similar CANMET activities assisted your firm in any way? How?

B9 In your view, what types of assistance, from a program such as CANMET's FFHP, would best enable your firm to continue to develop competitive new energy efficient home heating products?

B10 Do you have any additional comments?

Thank you!

APPENDIX B
ADDITIONAL PROGRAM DOCUMENTATION

APPENDIX B-1: R&D CONTRACTS

APPENDIX B-1
CCRL - FFH PROGRAM
RESEARCH AND DEVELOPMENT ACTIVITIES
- CONTRACT SUPERVISION -

Date Initiated	Title	Contractor/Beneficiary
1985/86	Gas Furnace Condensing Flue Retrofit: Phase III	Clare Brothers
1985/86	Advanced Heat Exchangers for Gas Furnace & Boilers: Phase IV.	Consumers Gas Spyder Engineering
1985/86	Field Test of Advanced Gas-Fired Appliances: Phase II.	Consumers Gas
1985/86	Advanced Efficiency Oil Furnace and Water Heater	Clare Brothers
1985/86	Application of Flue Gas Condensing Systems to Gas-Fired Boilers	Kent Engineering
1985/86	Update Combustion Handbook for Canadian Fuels	Canadian Institute of Energy
1985/86	Field Trial to Determine Effects of Catalysts and Advanced Designs on Wood-Burning Appliance Efficiency and Emissions	Omni International

1985/86	Indoor Air Quality as Affected by Combustion Appliances	Enerplan Consultants
1985/86	Potential for Backdrafting in Problem Housing	Retrospectors Inc.
1985/86	Thermodynamics of Vents and and Flues	Scanada Consultants
1985/86	Direct Vent and Induced Draft Fan Water Heater Trials	Ontario Research Foundation
1984/85	Gas Furnace Condensing Flue Retrofit	Clare Brothers
1984/85	Advanced Heat Exchangers for Gas Furnace and Boilers	Spyder Engineering
1984/85	Field Test of Advanced Gas-Fired Appliances	Consumers Gas
1984/85	Hazardous Heating and Ventilating Conditions in Houses	Canada Mortgage and Housing Corporation
1984/85	Field Evaluation of Residential Ventilation Systems Guidelines	HUDAC
1984/85	Potential for Backdrafting in Problem Housing	Canada Mortgage and Housing Corporation
1984/85	Canadian Builders Survey for High Efficiency Housing	HUDAC

1982	Field Trial of Condensing Flue Refrofit	CANMET/Clare Brothers
1982	Field Performance of Advanced Pulse Combustion Furnace	CANMET/Consumers' Gas
1982	Advanced Plastic Condensing Furnaces	CANMET/Consumers' Gas/Spider
1981	Field Test of Advanced Gas-Fired Appliances	CANMET/Consumers' Gas
1981	Advanced Heat Exchangers for Furnaces and Boilers. Phase I.	CANMET/Consumers' Gas/Spider
1981	Hazard Potential of Wood Add-on-Furnaces	CREB/CSA
1981	Efficiency Potential of Fireplace Inserts	CREB/CES Halifax
1981	Ultrasonic Modulating Oil Burner	CANMET/Global
1980	Gas Furnace Condensing Flue Retrofit Design	CANMET/Clare Brothers
1979	Retrofit Kit for Oil Burners	CANMET/AERO
1979	Field Performance of Add-on Heat Pumps to Oil and Gas Furnaces	CEA/Wardrop Associates
1979	Low Output Oil Furnace	CANMET/Enterprise

APPENDIX B-2: REPORTS, PUBLICATIONS, MANUALS

APPENDIX B-2
CCRL-FFH Program
INFORMATION TRANSFER ACTIVITIES
- Reports, Publications, Manuals

1986

Emissions and efficiency of wood-fired central heating appliances. Proceedings - Combustion Emissions from Residential Space Heating and APCA Paper 86-12.7; Annual Meeting of Air Pollution Control Association (APCA); Minneapolis, June 1986.

Central wood furnaces, because of their cyclic on/"stew" operation in response to thermostat control, have the potential to be major emitters and creosote generators, while suffering efficiency penalties. Determination of their seasonal performance requires a combination of the cyclic procedure developed for gas furnaces with the fuel composition change developed for wood stoves.

This paper was of interest to furnace manufacturers, giving them a guide on how to improve the design and operation of their appliances, and to regulators, to determine feasible techniques to control the emissions from such units.

Improved fuel utilization efficiency through combined space and water heating; Proceedings, Combustion Institute, Canadian and Western States Section Spring Technical Meeting; Banff, Alberta, April 1986.

With the lowered energy requirements of new homes, energy consumption for tap water heating is approaching that for space heating. To have two separate systems to supply each energy requirement is costly and may not be the most energy efficient procedure. This paper describes the innovative features of two combined space/tap water units, one condensing and one non-condensing. Both show very high seasonal efficiencies and offer potential new technologies to this changing marketplace.

This paper is of interest to manufacturers, offering them an expanding market, to homebuilders who must supply the customer with a satisfactory product and to special programs, such as R2000, who are encountering this dilemma at the moment.

Residential gas-fired combustion systems and indoor air quality; Proceedings, Annual Technical Meeting of the Ontario Natural Gas Association; London, Ontario, September 1986.

With the increased interest in energy conservation, homes are being made tighter with more insulation and weatherstripping. Naturally aspirated gas-fired furnaces and water heaters can experience spillage of combustion products into the house if draft is not adequate, if there are too many other exhausting appliances, such as kitchen and bathroom fans, dryers, etc., and/or if the house is too tight. The various actions presently underway, from regulatory, standards and technology points of view to ameliorate the problem are presented, including retrofit techniques to improve existing appliances.

This paper was of interest to utilities, equipment manufacturers, regulatory and building officials, and home builders.

Experimental Program for the evaluation of fuel quality effects on burner performance; Paper SF-86-14 and Proceedings ASHRAE Annual Meeting, San Fransisco, January 1986.

This paper gives a detailed description of the experimental facilities and procedures developed for a research program to evaluate middle distillate combustion performance. Special emphasis was made to ensure that the experimental conditions were representative of residential use. The experimental rig included a domestic warm air furnace, fuel-temperature-controlling equipment, a special cold air return system, continuous analyzers for gaseous emissions and temperatures and a unique system to monitor the soot production on start-up and shut-down.

The program is being conducted under the auspices of the CGSB Middle Distillate Fuels Committee, with the goal of determining limits for fuel properties to ensure satisfactory performance and maximum effective utilization of fuel.

Effects of middle distillate fuel properties on residential oil combustion characteristics; Paper PO-86-06 and Proceedings, ASHRAE Annual Meeting, Portland, Oregon, June 1986.

The exerimental program on middle distillate heating fuels at CCRL is designed to determine the effects of degrading fuel properties on combustion. Test procedures are described and cyclic results of gaseous and solids emissions are presented, for a range of 22 fuels and blends. Results have shown that increased aromatics and viscosity can lead to problems with conventional residential oil burners, particularly with cold system start-up and cycling.

The paper is of interest to oil refiners in determining ranges of blending stock suitable for residential heating applications, to maximize the crude oil barrel and to equipment manufacturers.

Determination of fuel aromatic content and its effect on residential oil combustion; Proceedings, American Chemical Society Annual Meeting, Anaheim, California, September, 1986.

The aromatic properties of middle distillate fuels are determined using a range of techniques, including FIA, PNMR, GC/MS, MS, theoretical calculations and aniline point, and are compared with the results from a number of CCRL combustion experiments. In particular, a breakaway point seems to occur at about 45% aromaticity, equivalent to 60% aromatic content.

The paper is of interest to oil refiners in determining limits of middle distillate fuels and in deciding which technique is most suitable for determining the critical properties.

1985

Determination of emissions and efficiency of wood-fired central heating appliances. Proceedings - Combustion Emissions from Residential Space Heating and APCA Paper 85-43-4; Annual Meeting of Air Pollution Control Association (APCA); Detroit, June 1985.

Central wood furnaces, because of their cyclic on-"stew" operation in response to thermostat control, have the potential to be major emitters and creosote generators, while suffering efficiency penalties. Determination of their seasonal performance requires a combination of the cyclic procedure developed for gas furnaces with the fuel composition change developed for wood stoves. This paper was of interest to furnace manufacturers to improve the design and operation of their appliances, and to regulators to determine feasible techniques to control the emissions from such units.

Potential problems, solutions and R & D needs for chimneys, vents and flues in Canada. Canadian Electrical Association - Canadian Standards Association Joint Technical Meeting on Chimneys; Toronto, January 1985.

This paper examines the problems that may occur with masonry and prefabricated metal chimneys, in both new and existing installations. It presents the operational characteristics of fossil fuel - and wood - fired appliances in relation to the chimneys they feed. Both steady state and cycling characteristics are important. Changes in fuel, the use of mixed energy sources and improvements in efficiency have all affected the chimney environment. Existing chimneys are seen to have many defects, some caused by poor construction, some caused by mismatching with appliances. Moisture damage, usually from the flue gas, is seen as a major cause of chimney failure. Modifications to the venting system, such as relining and repair, or the use of additional metal liners may improve the chimney performance.

The effects of residential combustion systems on indoor air quality. Proceedings, Annual Technical Meeting of the Ontario Natural Gas Association. Toronto, September 1985

With the increased interest in energy conservation, homes are being made tighter with more insulation and weatherstripping. At the same time, combustion appliances are having an increasingly difficult time receiving adequate air to operate safely and properly. The various combustion systems found in Canadian homes have large differences in their air requirements, with implications for efficiency. Cold outside air must enter the house, be warmed up to room temperature and then immediately exhausted up the chimney. More importantly, it raises serious questions of the ability of tight housing to supply that air, with implications for the health of the inhabitants.

This paper was of interest to regulatory and building officials, home builders, utilities and equipment manufacturers, all of whom are subsequently modifying their concepts of how air should be supplied to combustion appliances.

Wood stove operation and advanced design to reduce emissions of incomplete combustion products. Proceedings, North East Wood Combustion Conference. Amherst, Massachusetts, April 1985.

The high emissions from residential wood burning are due to incomplete combustion, resulting from design shortfalls in present appliances. The paper shows that emissions increase significantly when the firing rate of an appliance is reduced below a certain level, the "critical burning rate". Performance data of new combustion designs which offer potential to reduce these emissions are presented.

While new designs are important, emissions from presently-installed equipment can be reduced if the firing rate is not kept above the "critical rate" of the typical overnight burn condition. One way is to reduce the effective heat transfer surface of the appliance by the use of double-walled flue pipe in place of single-walled pipe from the appliance to the chimney, forcing the stove itself to be run hotter, in a more efficient condition. Other techniques for reducing existing emissions are also presented. There are two additional benefits: (i) efficiency will be increased; and (ii) the propensity to produce creosote will be decreased, making the appliances safer to operate.

Advanced technology to improve oil furnace performance. Proceedings, American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) Energy Efficiency Conference, Toronto, April 1985.

Conventional heating systems operate at a low seasonal efficiency, well below their steady state efficiency. Changes in technology offer significant reductions in fuel consumption by improving combustion performance, reducing off-cycle losses, eliminating the need for downstream infiltration of dilution air and increasing dramatically the steady state efficiency with more heat exchange surface, to even condense the combustion products and recover the latent heat. CCRL is conducting a major research program to develop the most promising of the new technologies and to determine their performance, both in the laboratory and in the field, under real-life conditions. This paper summarizes the activities and accomplishments to date and presents directions for future research.

Efficient combustion systems for oil heating. Proceedings, Oil Heat Technology Conference, U.S. Department of Energy, Brookhave Nation Laboratories, Upton New York, September 1985.

A new design of oil furnaces, based on the induced draft fan concept, which eliminates the major air requirement - the barometric damper - provides positive exhausting of the combustion products, allows more heat to be taken out of the flue gases and eliminates most off-cycle losses. Potential efficiencies are near those of condensing gas furnaces, without the problems nor additional costs of actually condensing the flue gases.

Seasonal efficiency standard - a requirement for oil furnaces. Canadian Standards Association Steering Committee on Combustion and Fire Safety, January 1985.

There is potential for significant reductions in energy consumption by improving the efficiency of residential oil-fired heating systems. Presently residential oil furnaces in Canada are compared only on the basis of their steady state efficiencies. Such a measurement neglects cyclic and off-cycle performance, as well as the effect of dilution air. On the other hand, a seasonal efficiency standard would take these factors into account. It is possible to have two furnaces with the same steady state efficiency, yet with 10-20% differences in their actual seasonal performance, due to differences in technology. Unless an equitable, accurate method to label their seasonal efficiency is developed, there may be little incentive for manufacturers to produce a truly more efficient product, one which may be safer as well as being compatible with the more energy efficient housing now being built.

The paper presents techniques to enable the Canadian Standards Association to develop a seasonal efficiency standard for oil furnaces.

1984

Air demands of residential combustion appliances. Proceedings - Combustion Emissions from Residential Space Heating and APCA Paper 84-32.1; Annual Meeting of Air Pollution Control Association; San Francisco, June 1984.

With the increased interest in energy conservation, homes are being made tighter. At the same time, combustion appliances are having an increasingly difficult time receiving adequate air to operate safely and properly. The various combustion systems found in Canadian homes have large differences in their air requirements, with implications for efficiency. Cold outside air must enter the house, be warmed up and then immediately exhausted up the chimney. More importantly, it raises questions of the ability of tight housing to supply that air, with implications for the health of the inhabitants. This paper was of interest to regulatory and building officials, home builders, utilities and equipment manufacturers, all of whom are subsequently modifying their concepts of how air should be supplied to combustion appliances.

Methanol: an efficient fuel for domestic heating. Proceedings, VI International Symposium on Alcohol Fuels Technology; Ottawa; May 1984.

Methanol may be most effectively used as a domestic heating fuel. Using a flame retention head burner and the CCRL retrofit condensing system developed for existing gas furnaces, an oil furnace can be modified to burn methanol at over 90% efficiency. Having a higher hydrogen content than natural gas, methanol makes an ideal clean fuel for condensing applications. This is one of the few applications for methanol where there is a major end-use efficiency advantage, offsetting the energy used to produce the methanol.

It is attractive to those remote regions of the country where gas lines will not be available and on-site fuel storage is a requirement.

Development of an emissions/efficiency standard for wood-fired appliances. Proceedings - Combustion Emissions from Residential Space Heating and APCA Paper 84-70.4; Annual Meeting of Air Pollution Control Association; San Francisco; June 1984.

A draft standard has been developed to measure efficiency, emissions and heat output at low, medium and high burn rates, using a heat loss method based on a continually varying fuel ultimate analysis. It is a procedure by which all Canadian Stoves can be measured and compared in the marketplace. Consumers can choose between two stoves of the same nominal efficiency or heat output, on the basis of the amount of incomplete combustion products and, hence, on the potential for chimney fires from creosote and the pollutant emissions to the environment. It also presents regulators with the possibility of placing minimum levels of emissions in certain applications, such as areas with poor fumigation (eg. sub-Arctic or certain river valleys), or as eligibility criteria for assistance under government programs.

Efficient residential heating systems. Office of Energy Research and Development; Ottawa; May 1984.

Conventional heating systems operate at a low seasonal efficiency, well below their steady state efficiency. Changes in technology offer significant reductions in fuel consumption by improving combustion performance, reducing off-cycle losses, eliminating the need for downstream infiltration of dilution air and increasing dramatically the steady state efficiency with more heat exchange surface, to even condense the combustion products and recover the latent heat. The incumbent in directing a major research program to develop the most promising of the new technologies and to determine their performance, both in the laboratory and in the field, under real-life conditions. This paper summarizes the activities and accomplishments to date.

Development of a furnace with a low temperature plastic heat exchanger. Proceedings, International Gas Research Conference; Washington; September 1984.

A novel condensing gas furnace has been developed, using plastic as the condensing heat exchanger, with a patentable flue gas recirculation system-controlling the inlet temperature to the plastic. The material offers cost advantages over present stainless steel designs. At the same time, its resistance to potential chloride corrosion arising from household cleaners, solvents and bleaches may make it more attractive in the long term.

The paper was of considerable interest to furnace manufacturers, gas utilities, the American Gas Association and the U.S. Department of Energy, who are all very concerned over the potential chloride problem.

1983

Extended use of plenum heaters in oil-fired heating systems: implications for chimney integrity. Proceedings of International Dual Fuel Symposium, Toronto, October 1983.

Chimney deterioration may increase with increased plenum heater use. If run with a lower outside temperature set-point, moist house air may flow up the chimney, condense and migrate into the mortar, causing deterioration. In the worst case, the interior of the chimney might collapse and cause flue blockage. This may occur in chimneys that are in good condition; defective chimneys, of which there are a large number, would be even more prone to this problem and should be repaired before a plenum heater is installed. A more severe problem may exist with a different type of control strategy - a two stage thermostat operation throughout the winter. This may result in continuing condensing conditions when the oil furnace is firing on a reduced cycle length in cold ambient temperatures. Under such conditions, rapid chimney deterioration is possible. To minimize chimney problems, the oil furnace should be run for a fixed period every day, say between 1600 and 1900 hours, each day of the heating season, to dry out the chimney regularly, while also operating with a low outside set-point the rest of the time. This might even have an electrical demand benefit for the local electric utilities.

This paper was of prime interest to electric utilities, regulatory officials, oil companies and Federal officials involved in the Off-Oil program.

Air requirements of combustion systems. Proceedings, International Conference on the New Neighbourhood, Toronto, Ontario, February 1983.

With the increased interest in energy conservation, homes are being made tighter with more insulation and weatherstripping. At the same time, combustion appliances are having an increasingly difficult time receiving adequate air to operate safely and properly.

The various combustion systems found in Canadian homes have large differences in their air requirements, with implications for efficiency. Cold outside air must inter the house, be warmed up to room temperature and then immediately exhausted up the chimney. More importantly, it raises serious questions of the ability of tight housing to supply that air, with implications for the health of the inhabitants.

This paper was of interest to regulatory and building officials, home builders, utilities and equipment manufacturers, all of whom are subsequently modifying their concepts of how air should be supplied to combustion appliances.

Fuel variation through the burning cycle: implications for indirect efficiency measurements. Proceedings, Annual Technical Meeting of Wood Heating Alliance, Baltimore, March 1983.

Experiments on wood stoves have been carried out whereby the fuel has been quenched at various points through the burning cycle and the changes in ultimate analysis determined. The instantaneous heat losses and quantities of incomplete combustion products are based on this varying fuel composition. This allows detailed evaluation of combustion system performance, rather than merely relying on average performance over a complete burn, giving manufacturers better guidance on how to improve performance. Detailed experimental results on the changes in fuel composition and heating value, progressing to almost pure carbon by the end of the cycle, are given in this paper.

Development of an emissions/efficiency standard for wood-fired appliances. Proceedings - Combustion Emissions form Residential Space Heating and APCA Paper 54.9, Annual Meeting of Air Pollution Control Association, Atlanta, June 1983.

A draft standard has been developed to measure efficiency, emissions and heat output at low, medium and high burn rates, using a heat loss method based on a continually varying fuel ultimate analysis. It is a procedure by which all Canadian stoves can be measured and compared in the marketplace. Consumers can choose between two stoves of the same nominal incomplete combustion products and, hence, on the potential for chimney fires from creosote and the pollutant emissions to the environment. It also presents regulators with the possibility of placing minimum levels of emissions in certain applications, such as areas with poor fumigation (eg. sub-Arctic or certain river valleys), or as eligibility criteria for assistance under government programs such as COSP.

Energy conservation R & D on heating systems at CCRL. Proceedings, Buildings Energy Conservation Policy Forum, National Research Council, Ottawa, May 1983.

Conventional heating systems operate at a low seasonal efficiency, well below their steady state efficiency. Changes in improving combustion performance, reducing off-cycle losses, eliminating the need for downstream infiltration of dilution aire and increasing dramatically the steady state efficiency with more heat exchange surface, to even condense the combustion products and recover the latent heat. CCRL is conducting a major research program to develop the most promising of the new technologies and to determine their performance, both in the laboratory and in the field, under real-life conditions. This paper summarizes the activities and accomplishments to date.

Performance and emissions from residential wood-burning appliances. Proceedings - U.S. Environmental Protection Agency Workshop on Residential Solid Fuels, Portland Oregon, November 1983.

Air pollution from wood-fired appliances has become a major concern of regulatory authorities in many areas of the United States and Canada, and has caused some to seriously consider banning their use, at least in critical regions.

This plenary paper describes the emissions from wood burning appliances due to incomplete combustion, resulting from design shortfalls in present appliances. Emissions of concern are carbon monoxide and unburned hyrdrocarbons, including what are known as POM's (polycyclic organic matter), where known carcinogens have been identified as prime constutents. The levels and problems which can occur from these emissions are discussed in comparison with althernative energy sources. New combustion designs which offer potential to reduce these emissions are also presented. Any technique which does succeed in reducing emissions has two additional benefits: efficiency will be increased and the propensity to produce creosote will be decreased, with obvious safety implications.

Effects of plenum heaters on venting systems. Canadian Electrical Association Paper 237 USOA, May 1983.

Plenum heaters may cause increased chimney deterioration, if they are to displace oil merely by having a lower outside temperature set-point. The problem is likely to be accentuated by increased tightening of homes which will increase indoor humidity levels, resulting in high moisture flows up a cold chimney during prolonged off periods, with probable condensation.

Although there is the possibility that ice blockage might occur at the top of the chimney, this is not considered to be a likely occurence, except in extreme conditions.

Changes in fuel composition over the burning cycle of domestic wood. Proceedings 1983 Technical Meeting, Combustion Institute-Canadian Section, Kingston, May 1983.

Experiments have been carried out at CCRL whereby the fuel has been quenched at various points through the burning cycle and the changes in composition determined, in terms of ultimate analysis, energy content and moisture level. The implications on instantaneous heat losses and quantities of incomplete combustion products, as determined by an indirect heat loss technique, are discussed. The procedure allows detailed evaluation of combustion system performance at any point in the burning cycle, rather than merely relying on average performance over a complete burn, giving researchers and designers better guidance on how to improve performance.

Air requirements of residential combustion systems. Proceedings 1983 Technical Meeting, Combustion Institute-Canadian Section, Kingston, May 1983.

Central furnace/boilers fired by gas or oil have two distinct air demands - combustion and dilution. The combustion air is brought into the appliance at the burner, mixed with the fuel and ignition occurs. The excess air and combustion products pass through the heat exchanger before venting. Dilution air is brought in downstream of the furnace proper, after the heat exchanger, and is used to isolate the burner from outside pressure fluctuations. The major air flow is for dilution, two to ten times that required for combustion. New medium and high efficiency gas furnaces have eliminated the dilution device by having a high pressure forced exhaust system. The air demands of such systems are thus much lower. Of any household appliance, the fireplace requires the most air, typically operating at excess air levels of 1800%. High burning rates make their total air requirement even greater. Airtight wood stoves do not require dilution air, operate at low firing rates and have excess air levels on the order of only 100%.

An efficiency/completeness-of-combustion standard for wood-fired appliances. Proceedings Annual Meeting of Canadian Wood Energy Institute, Toronto, June 1983.

CCRL has been carrying out a detailed research program on domestic wood-fired appliances since 1977. One of the goals has been to develop a straightforward test procedure to determine the efficiency of controlled combustion space heaters. A parallel goal has been the characterization of the combustion and emissions of these appliances. The procedure developed uses an indirect technique, such as a calorimeter room, which only looks at efficiency and heat output can be misleading. It is possible to increase efficiency by merely adding on more heat exchange surface, increasing the possibility of creosote deposition, and even emissions.

Potential for methanol as a domestic heating fuel. June 1983.

CCRL has developed a retrofit condensing system for residential warm air furnaces, which can be retrofitted to existing oil furnaces. Using a flame retention head burner, with the pump modified to allow for the low lubricity of methanol, methanol can be fired easily. Efficiencies are increased dramatically, above that achievablea with natural gas in the new condensing furnaces. This is one of the few applications for methanol where there is a major end-use efficiency gain, offsetting the energy use to produce the methanol in the first place. It is attractive for those areas of the country where gas lines will not be available, where on-site fuel storage is a requirement and where electricity is not a satisfactory alternative for heating.

Combustion air requirements of residential heating systems - hazards and solutions. July 1983.

Small airtight wood stoves or high efficiency gas or oil furnaces which have no dilution air requirement are seen to have no significant air demand. Conventional oil and gas furnaces have air demands on the same order as that of a fairly tight house (about 0.5 air changes per hour), while a fireplace may have air demands as much as three times that which a tight house can supply. Solutions to the problem, either by new technology, modification of lifestyle or retrofit are presented.

Efficient oil-fired residential heating systems. September 1983.

Conventional oil heating systems operate as much as fifteen percentage points below their steady state efficiency level. Changes in technology of major fuel economies, by reducing excess air requirements, eliminating the dilution air requirement of the barometric damper, lwering off-cycle losses and increasing heat exchange surface. A retrofit package has been developed to lwer excess air by means of the flame retention head burner. Further promising improvements are by means of an induced draft fan package or a condensing furnace.

1982

Air pollution from domestic wood-burning appliances. 1982 Annual Technical Meeting, Atlantic Air Pollution Control Association, September, Paper 82-45, pq. 130-142.

This paper compares the pollution potential of domestic wood stoves and furnaces with the oil furnace they might displace; conventional wood stoves are shown to have much higher levels of carbon monoxide, hydrocarbons and polycyclic organic matter, while SO_2, NO_X and solids emissions are markedly lower. New techniques for wood combustion are shown to lower CO and HC emissions by about 70%, bringing them more in-line with the other fuel sources.

This paper was of interest to regulatory officials, manufacturers and consultants in the Maritimes, has resulted in two furnace boiler manufacturers changing design and in specific air shed emissions measurements being set-up for areas where high wood burning concentrations exist.

Potential alternate domestic heating fuels. Proceedings, Annual Meeting, Combustion Institute, Canadian Section, May, 1982, pg. 26-31

This paper presents experimental results on the use of methanol in condensing furnaces. Because of the high moisture content in the flue gas, the dewpoint is higher than for natural gas, and a much greater proportion of water vapour is condensed. The same furnace fired with methanol shows an efficiency of 95%, as opposed to 90% when fired with gas. The potential of two vegetable oils, sunflower and conola as a No. 2 oil substitute is discussed. Sunflower oil shows some potential in blends, but the performance of canola oil is unsatisfactory.

This paper has generated interest in methanol as a domestic fuel with efficiency advantages in areas of Canada not connected to gas, and in other parts of the world where alcohol fuels are available from renewable sources.

Effects of firing rate and design on domestic wood stove performance. Proceedings Combustion Emissions from Solid Fuel Fired Appliances. Specialty Meeting, Air Pollution Control Association, Louisville, Kentucky, pg. 56-69.

This paper presents the results of a detailed experimental program at CCRL on the emissions characteristics of domestic wood stoves. In particular, emissions of CO hyddrocarbons and POM's are shown to increase significantly below a critical firing rate of ~3 kq/h. On the other hand, the heat demand in most Canadian homes is below 2 kq/h for most of the year. Research designs using catalyst or downdraft into refractory combustion show a lowering of the general emission levels, as will as a reduction of the critical firing rate.

Potential of vegetable oils as a domestic heating fuel. Air Pollution Control Association APCA 82-19.1. 1982 Proceedngs Combustion Emissions from Residential Space Heating. New Orleans, Louisiana, pg. 12-26.

This paper presents experimental data on the burning of canola and sunflower oils neat and in blends with No. 2 oil, fired in a retention head burner-equipped domestic warm air furnace. With increased pressure and nozzle pre-heat sunflower oil performs well in blends up to 50%. Canola oil is only suitable in blends of 10%. The degree of fatty acids appears to be the dominant factor in fuel performance. In agricultural regions, sunflower oil has the potential to displace a significant quantity of middle distillate fuel.

This paper has been of major interest to the Canadian Agricultural Community, to mid-western States in the US and to a number of developing countries, offering a means of increasing energy self sufficiency.

Performance of condensing domestic gas-fired heating equipment. Paper 82-83; Proceedings International Symposium on Condensing Heat Exchangers, Atlanta, Georgia, pg. 73-88.

This paper details new designs for gas furnaces which condense the combustion products therby gaining higher efficiency from the latent heat. It presents experiments which show that present techniques being developed in the US to measure the seasonal performance of these appliances are incorrect and presents a more accurate procedure. Contrary to conventional furnaces, condensing units are more efficient on short cycles, because colder metal temperatures condense more water. A new plastic condensing furnace is also described.

This paper was of great interest to equipment manufacturers, some of whom have changed future product line directions; also, US Department of Energy has modified its seasonal performance standard as a result.

Emissions from domestic wood burning system - problems and potential solutions. Paper 82-24. Proceedings CWEI Annual Meeting Woodfire 1982, pg. 190-212.

This paper describes comparative emissions from various domestic heating options and presents experimental laboratory data for emissions from a series of state-of-the-art and advanced design wood stoves. New designs offer promise of low emissions and high efficiency at the low output rates more suitable to Canadian home requirements.

1981

Methanol as a domestic heating fuel. Air Pollution Control Association; APCA Paper 81.8.6 and Proceedings 1981 Combustion Emissions from Residential Space Heating, Philadelphia, PA, pg. 73-87.

This paper describes how methanol can be substituted for No. 2 oil in domestic furnaces with only minor modifications to existing equipment. Test results indicated that performance with methanol is competitive with exisitng fuels, provided the burner is fitted with a flame retention head. At the same time, methanol allows much greater range in furnace sizing, due to the lower HHV of methanol. In addition, methanol offers the potential of clean burning fuel with low emissions of carbon monoxide, hydrocarbons and nitrogen oxides. With its high H/C ration, with the high related latent heat loss, a technique to regain this heat with a condensing furnace, developed for gas under contract to CCRL, was proposed in the paper.

Large interest has been shown in this paper by US officials and manufacturers, as well as certain provincial governments. In particular, Mabitoba and the North West Teristories are seriously considering this as a means of freeing up premium deisel fuel for the transportation sector, while gaining domestic heating efficiency.

Oil burner retrofit to save energy and reduce emissions. 1981 Air Pollution Control Association: APCA Paper 81.8.1 and Proceedings 1981 Combustion Emissions from Residential Space Heating, Philadelphia, PA, pg. 1-15.

This paper describes three techniques to retrofit existing oil burners: replacing the conventional head with a flame retention head: downsizing the firing rate and using a delayed action solenoid valve. The performance of existing equipment in Canada is defined by a national survey of over 14,000 homes. Laboratory and field trials, coupled with the survey results, show anticipated average fuel savings of over 15%, with similar reductions in SO2 and NOX emissions. Even greater reductions.

Domestic oil heating system retrofit to save energy. Proceedings International Energy Agency Symposium on New Energy Conservation Technologies. Berlin, Germany, pg. 401-411.

This paper describes the significant fuel savings that are available by modifying existing domestic oil heating systems. Replacing the conventional oil burner head with a flame retention head yields fuel savings of 8% to 15%. Also, firing rate reductions of as much as 50% are possible, making the furnace output more compatible with the house heat demands, yielding further fuel savings of 5%-10%. Laboratory results are complemented by measurements from long-term field trials in real-life instrumented homes.

From this paper, US officials are examining the possibility of setting up a similar program to retrofit retention heads on oil-fired furnaces and boilers. The work has received strong praise from a recent Department of Energy review of the potential for increasing the efficiency of oil-fired systems.

Efficient gas-fired residential heating systems. Proceedings Spring Technical Meeting of Combustion Institute. Paper C14-29, pg. 26-31.

Conventional gas-fired heating systems operate at a relatively low seasonal efficiency, well below their steady state efficiency. This paper shows how changes in technology an offer significant reducdtions in fuel consumption by improving combustion performance, reducing off-cycle losses, eliminating the need for downstream infiltratin of dilution air and increasing dramatically the steady state efficiency with additional heat exchange surface.

This paper has resulted in Canadian manufacturers realizing some of the potential techniques to improve the efficiency of their products and they are now engaged in a major re-design to take these into account. Potential fuel savings by these modifications are in the range of 20% to 40%.

Domestic wood-fired appliances. Proceedings EPA Conference on Wood Combustion Environmental Assessment. New Orleans, LA, pg 152-169.

This paper discusses the results of CCRL's experimental testing program for various wood stove designs, in terms of both efficiency and emissions. Stoves and improved combustion design, specifically the side draft or horizontal baffle types, show much reduced emissions while having high efficiency. Laboratory results are supplemented by field trails in a number of homes; results indicate that a well designed wood stove, properly located, can be an efficient means of reducing demand for premium fuels for domestic heating.

Factors affecting wood stove design & performance. Wood Heating Seminar, VII, US Wood Heating Aplliance, pg. 16-43.

This paper described different combustion systems for domestic wood burning and their potential for achieving completeness of combustion and high efficiency. Freestanding fireplaces and non-airtight stoves were shown to have similar poor efficiencies of 20% to 30%, while airtight units have efficiencies from 50% to 77%. Unbaffled box stoves have the highest emissions and lowest efficiencies of the airtights. Most central wood-burning furnaces also have similar designs, and hence show relatively poor performance with relation to efficiency and creosote production. Sidedraft and horizontal baffle designs show the best efficiency and lowest emissions levels.

As a result of this paper, the incumbent is called onto advise various international manufacturers improve their product and to set up test facilities, both in other government agencies and in priate industry to measure same.

Efficient wood stove design and performance. Proceedings NRC Bioenergy R&D Seminar, pg 79-92.

This paper describes laboratory trials conducted at CCRL with a range of wood burning space heaters. Controlled combustion appliances all operate at an efficiency at least twice that of non-airtight units. However, non-baffled units and presently available downdraft designs had considerably higher emissions of incomplete combustion products, which can lead to safety hazards. Existing designs which show improved combustion performance are the sidedraft and horizontal baffle types.

This paper has led officials concerned with biomass energy utilization to recognize that domestic wood heating can play a significant role in reducing consumption of premium fuels in this area and to investigate support for their safe use.

1980

Domestic wood combustion. Manual from seminar Wood: An energy Resource for Domestic and Industrial use. Sponsored by State Pacific North West and Washington State University, Seattle, Washington. Publication WA80-312, pg. 210-226.

This paper summarizes the test procedure developed by CCRL to measure wood space heater performance and examines the effect of various combustion designs on performance in terms of efficiency and emissions.

For controlled combustion appliances, efficiency is maximized over a fairly narrow range of firing rate, while emissions tend to continually decrease with increased firing rate for any specific appliance. The largest performance variation occurred between different updraft stoves. Emission levels show a strong relationship to stove type, with the sidedraft showing the lowest emissions and highest efficiency.

Efficient residential oil-heating systems

This book is a manual for servicemen, designers and builders on how existing oil heating systems function and various system and hardware modifications which can be applied to improve their seasonal efficiency by as much as 25%.

Wood stove design and performance. Proceedings of Annual Meeting of US Wood Energy Institute, Atlanta, pg. 119-136.

Effect of wood stove design on performance: l'influence du type de poele a bois. Proceedings of Annual Meeting of Canadian Wood Energy Institute, pg. 82-108.

Free standing fireplaces and non-airtight space heaters have essentially similar performance, showing low efficiencies. The better existing side-draft and horizontal baffle designs offer appliance efficiencies of over 70%, while having 1/3 to 2/3 less emissions of incomplete combustion products. From a field trial, the best performing sidedraft stove was shown to have a seasonal efficiency of 65%, above that of an oil or gas central heating system.

Wood stoves:efficient design and performance. Information EMR, 42 pg.

This summary of wood space heating performance results was assembled for national distribution for Energy Conservation Week by Info EMR and has been used as a reference manual for seminars conducted by ACS Hayden and policy representatives to representatives of all provinces as part of the federal Off-Oil program as well as to field representatives of EMR.

Performance of synthetic fireplace logs in a non-airtight woodstove.

1979

Wood-fired appliances: efficiency measurement. Installation, operation and maintenance of wood-fired appliances. Course Test for Canadian Colleges by Canadian Wood Energy Institute, pg. 49-74.

This publication discusses what is meant by wood stove efficiency, gives four techniques on how this may be measured, outlines how wood stoves should be installed in a house to conserve energy, and establishes that built-in fireplaces actually increase fuel consumption; on the other hand, good wood stoves properly located can result in significant reductions in fuel consumption, and can have a seasonal efficiency higher than an oil or gas furnace.

Performance of retrofit flame retention heads in domestic oil furnaces.

This report evaluates the variations in performance between domestic oil burners with conventional heads and with flame retention heads when fired into two representative domestic furnaces. Gains in efficiency of more than 10% are realized with the retention head, while metal surface temperatures are at or below those of conventional heads. Further fuel savings are possible by downsizing of the firing rate.

This report has been used by senior EMR officials to convince Ontario regulatory officials that no safety hazard exists when CSA-approved retention heads are fitted to existing burners and to ensure that Ontario would participate in a nation-wide retrofit program of domestic oil furnaces to conserve oil.

Performance of compressed wood briquettes in wood stoves. Meeting the Challenge of Wood Energy. Proceedings of 1979 Annual Conference of Canadian Wood Energy Institute, pg. 84-107.

This paper presents experimental results on three designs of wood stoves burning both a dry hardwood (maple) and compressed wood briquettes. It showed that good combustion design is essential to complete burning of synthetic fuels. A potential fire hazard exists when burning the compressed wood briquettes in non-airtight appliances.

This information resulted in immediate modification of CSA codes on solid fuel fired appliances.

1978

Emissions and energy conservation in residential oil heating. Journal of the Air Pollution Control Association, Vol 28, No. 7, pg. 668-672.

This paper described strategies and technologies applied to domestic oil-fired heating systems in field trails which can result in fuel savings of more than 25% and significantly reduce pollutant emissions, at low initial cost.

Utilization of methanol in stationary source combustion. Volume 6 of Liquid Fuels in Ontario's Future. Advisory group on Synthetic Liquid Fuels for Ontario, Ontario Ministry of Energy. 36 pg.

This original overview report examines the potential of methanol as a fuel substitute in stationary source combustion. Methanol should only be considered for replacing premium fuels, middle distillates or natural gas. Fuel properties of methanol are ?

An evaluation of the Perolin BACO multipurpose fuel oil additive.

An evaluation of the Vasconol fuel oil additive.

Effect of fuel aromatic content on soot formation in a No. 2 oil combustion system.

On behalf of BP Canada, this paper shows that greater aromatic content, as is likely from increasing use of synthetic liquid fuels, can result in significant sooting in domestic systems fired with No. 2 oil.

1977

Oil conservation in domestic heating systems. American Society of Mechanical Engineers Journal of Engineering for Power, Vol 99, No. 7, July 1977, pg. 413-419.

This paper shows that flame retention head burners, coupled with reduced firing rate offer major fuel savings in oil heated homes. It has been the basis of a continuing effort by the incumbent and the department to carry on a major oil burner retrofit program in Canada and to upgrade the industry.

Effect of energy conservation strategies on emissions in residential heating and proceedings combustion emissions in residential space heating. Air Pollution Control Association Annual Meeting. APCA Paper 77-24.1 and 1977 Proceedings - Combustion Emissions from Residential Space Heating, pg. 14-28.

Utilization of methanol in stationary source combustion.

1976

Oil conservation in home heating. ASME Annual Winter Meeting 1976. Paper No. 76WA/Fu-8, 21 pg.

Field studies of oil consumption in homes which have been monitored over two heaing seasons were described. Twice daily recording of the fuel consumption, cycling frequency and burner cycle length, together with hourly meteorological data allowed establishment of baseline consumption data for comparison with the consumption levels resulting from the use of various conservation strategies. Improved burner performance, reduced firing rate, overnight thermostat cutback and positive chimney dampering all showed significant energy savings. Techniques developed by the incumbent for collection and analysis of date represent a departure from previous convention and provide valuable real-life information on technology advances.

1975

100 ways to save energy, pg. 11-41.

Detailed descriptions of domestic heating systems are presented; steps are outlined for their proper maintenance; suggestions are given for system modifications to improve the heating efficiency of the home and hence reduce energy comsumption. Most of the information was derived from information gained over the years from CCRL's research program and recent field experiments with domestic heating systems.

This booklet is now in its fifth printing, and over 1,200,000 have been distributed to homeowners across Canada.

Laboratory evaluation of Marois blue flame burner.

The Oil Heating Association of Canada Clean Air Program.
Phase VI: Assessment of Burner Performance (1975).

Noise Levels From Residential Oil Burners (1975).

Evaluation of the Blue - RAY BFH 0.75 and BFH 0.60 **Domestic Warm Air Heating Systems (1975).**

The performance of a Double-Wall PreFabricated Metal Chimney for Oil-Fired Residential Heating Applications.

1974

Evaluation of Burners with High and Low Speed Motors in a Domestic Hot-Water Heater (1974). Phase V: The Oil Heating Association of Canada Clean Air Program.

An Assessement of Burner Performance. **The Oil Heating Association of Canada Clean Air Program. (1974)**

Evaluation of Burners with High and Low Speed Motors in a Domestic Hot-Water Boiler (1974). Phase IV: The Oil Heating Association of Canada Clean Air Program.

1973

Facilities Techniques and Procedures. Phase I: March 1973. The Oil Heating Association of Canada Clean Air Program..

Evaluation of Burners with High-Speed Motors in Warm Air Furnaces. April 1973 Phase II. The Oil Heating Association of Canada Clean Air Program.

First Investigation Report - April 1973. The Oil Heating Association of Canada Clean Air Program.

Second Investigation Report - April 1973. The Oil Heating Associatin of Canada Clean Air Program.

Evaluation of Burners with Low-Speed Motors in Warm-Air Furnaces. Phase III: October 1973. The Oil Heating Association of Canada Clean Air Program.

Energy conversion and conservation, transformation et conservation d'energie. Proceedings ICFTC Eastern Canada Energy Conference, Montreal, 1973, pg. 75-113.

This was the first paper published in Canada which seriously examine the major potential for energy conservation to reduce premium fuel requirements.

It gave fuel consumption patterns to each sector of the Canadian economy in relation to total fuel reserves. It demonstrated dramatically, the urgent need for conservation of all fossil fuels and described practical methods for energy conservation, i.e. the use of coal-in-oil-fuel, better building insulation, improved combustion technology, and waste heat utilization. Finally, the projected energy savings that could result from these conservation strategies were predicted by mathematical modelling techniques.

1972

Some Performance Characteristics of Flame Retention-Head Domestic Burners - 20 pp. (1972).

The Performance of Vane Swirlers In Domestic Oil Burners - 20 pp. (1972).

Effect of fuel aromatic content on visible radiation from flames in a tobacco kiln.

Increased aromatic content in light oil used in tobacco kilns can result in total crop spoilage unless burner modifications and fuel control recommended in this report are followed. Results are also indicative of potential future problems in domestic heating systems.

APPENDIX C
COST-BENEFIT ASSUMPTIONS AND METHODOLOGY

APPENDIX C

ESTIMATION OF NET BENEFITS FOR MANUFACTURERS AND HOMEOWNERS

This appendix outlines the procedure which was followed for estimated the incremental program benefits associated with the manufacture and use of products that have been influenced by the Residential Fossil-Fuel Heating Program. The table below summarizes these benefits. The sources of information and procedures for calculating the entries in this table are outlined below.

Man.	Principal Product	Recent Year Units (000)	Export %	Program Relevant Sales $(000)	EE % of Product percent	Ass'd Incr %	Export Benefit $(000)	Present Value Savings $(000)
A	oil burners & kits	25	70	5000	99	40	$840	$8,197
B	gas furnaces	15	40	1700	35	50	$204	$1,748
C	gas furnaces	58	40	0	30	0	$0	$0
D	furnaces	9	10	0	0	0	$0	$0
E	woodstoves	4	0	1400	100	50	$0	$5,520
F	gas furnaces	11	0	120	100	5	$0	$611
G	woodstoves	10	0	2000	0	0	$0	$0
H	furnaces and boilers	3	5	1200	70	10	$4	$551
I	woodstoves & inserts	8	80	4500	20	5	$108	$44
J	oil B&F wood F&S	10	3	400	50	5	$0	$669
K	woodstoves & inserts	1.5	10	800	50	0	$0	$0
L	woodstoves & furnace	1.7	3	2000	100	10	$4	$455
M	oil furnaces +		5	1	6500	5	0	$0
$0								
						TOTAL:	$1,160	$17,795

1. The entries in the table are for all the manufacturing firms which were interviewed as part of this study. Although all manufacturing firms in Canada were not included in the interview sample, all firms (plus others) having significant direct contact with CCRL over the past 15 years were interviewed. For the purposes of estimating benefits related to the program, therefore, these firms represent the full population.

2. The number of units manufactured was determined as part of the interview. This number refers to the most recent 12-month period except in two cases where manufacture of these units has ceased. In these two cases, the number manufactured in the last year of production was taken.

3. The percentage of sales exported was determined as part of the interview.

4. The amount of sales relevant to the program excludes company sales of products that are not related to residential fossil-fuel heating.

5. The percentage of the firm's product that is considered to be "Energy Enhanced" was determined as part of the interview.

6. The incrementality of the program with respect to each firm was estimated subjectively based on the entire interview. In particular, reported year of first contact with CCRL, number of contacts per year, nature of contact or interaction and reported influence by CCRL were primary inputs to assessing this incrementality. Estimates for each firm were made as a "best guess" (nominal value) and as low and high estimates.

7. The value of the incremental export benefit was calculated as follows:

   o Export sales were calculated as export percentage times program relevant sales.

   o Export sales were multiplied by incrementality to get export sales attributable to the program.

   o 20% of attributable sales were defined as attributable export earnings.

   o These one-year earnings were multiplied by three to approximate the benefits over the full period during which the program has had and will have incremental influence.

   Nominal values for these export benefits were calculated using the nominal values of the assessed incrementality. Low and high estimates were calculated using the low and high estimates for incrementality.

8. The present value of incremental energy savings was calculated as follows:

- o The (one-year) number of energy efficient units manufactured and sold in Canada was calculated as the number of units manufactured times one minus the fraction exported times the fraction that were reported as being "Energy Enhanced".

- o This number was multiplied by the assessed incrementality for each firm.

- o Each unit was assumed to save, on average, 20 GJ of secondary energy per year relative to a conventional unit which would have been built (a low (15) and a high (25) value of energy savings were also applied).

- o The social opportunity cost (SOC) of the energy saved was calculated using EMR estimated SOC prices[1] of oil and gas used in the residential sector. SOC prices for oil and gas for the 20-year period 1986 to 2005 inclusive were present valued to 1987 using a seven percent real discount rate. The resulting present value of energy savings were $92 per annual gigajoule for oil and $37 per annual gigajoule for gas. For wood energy savings, the value for oil was applied.

- o The net benefit to the homeowner (and to society) resulting from the use of the energy efficient appliance must account for the initial cost of the appliance. This initial cost was set at one half of the energy savings, a value that is conservative and substantiated by other recent studies in this area. Thus the net benefit is one half of the energy savings.

- o The one-year value of net benefits is, therefore, the incremental number of units, times the energy savings per unit, times the SOC value energy savings per gigajoule, all divided by two to account for the initial cost of the appliance.

- o Finally, the total net benefit was estimated as three times this one-year value to reflect the benefit over the total program time period.

Nominal estimates of program benefits were calculated using nominal values of assessed incrementality and energy savings estimates (20 GJ). Low and high estimates were also calculated using, respectively, the low and high values of incrementality and the low and high values of energy savings.

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[1] Taken from Memoranda to Program Evaluation Group from Energy Strategy Branch dated May 30, 1986 and July 4, 1987.